GeoSierra

Newsletter

Spring 2004

Individual Highlights:

A Probabilistic Design Process is a Must for Iron PRBs

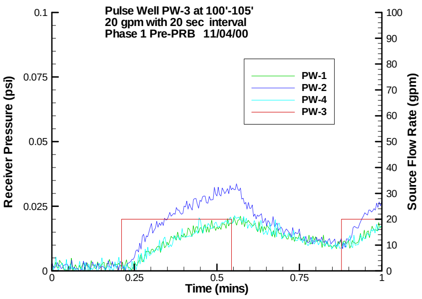
Permeable reactive barriers (PRBs) are high capital cost items, thus it is critical they be designed for maximum efficiency. There are two key criteria guiding the design of PRBs: cost efficiency and expected performance results, and they are closely linked. In order to achieve maximum cost efficiency, the PRB must not be excessively over-engineered beyond an appropriate safety factor. To ensure PRB target effluent concentrations (performance results) are achieved, the design of the PRB must incorporate an appropriate safety factor to provide sufficient confidence that the PRB will perform as expected and achieve regulatory requirements. Achieving this optimal balance between cost and performance requires a rigorous and reliable design process.

A Deterministic Design Process is Not Useful

The deterministic process is ideal for designing structures made from man-made materials engineered to handle specific stress loads i.e., weight, wind, air pressure, water pressure, etc. The known safety factors are "determined" from past experience depending on the type of structure; for example, a concrete pier supported bridge might have an arbitrary safety factor of 1.7, while a suspension bridge might have a safety factor of 4, or a passenger jet might be designed to accommodate significant turbulent conditions without failure.

Why Only Probabilistic Design Will Do for Designing PRBs

With PRBs the design input parameters vary with each site and cause associated uncertainties. Probabilistic design methodologies can accommodate multiple input parameter variability and associated uncertainties and are able to quantify the PRB engineered outcomes in terms of probabilities. The site-specific and variable design input parameters include formation, hydraulic conductivity, hydraulic gradients, groundwater flux and velocity, and porosity of the iron filings that will form the PRB. Additional design input parameters, which come from a bench scale column test, include volatile organic compounds (VOCs) and concentration levels, VOC degradation half-lives, the parent and daughter degradation pathways, and any groundwater chemistry issues that could negatively affect performance and/or longevity (precipitation or fouling) of the PRB. GeoSierra's probabilistic design model incorporates a multi-species first order VOC degradation model. A fate and transport model is also employed to determine VOC degradation by natural attenuation downgradient of the PRB. The probabilistic design model allows weighting of each parameter relative to its site-specific importance for design of the PRB. The model is computed by 85-percentile probabilistic distributions for target PRB effluent concentrations to determine the minimum thickness of the iron PRB wall. The properly designed thickness will ensure proper engineering of the PRB from a cost efficiency standpoint and will provide the required residence time within the PRB to bring VOC concentrations to below target levels.



Hydraulic Pulse Interference Test Results

Quality of Design and Construction QA/QC Processes Determine Ultimate PRB Performance

With the probabilistic design completed, thorough Quality Assurance/Quality Control (QA/QC) tools and processes are critically important for PRB construction to verify its in-situ placed dimensions are as specified by the design. The PRB installation method must cause minimal, if any, impact on the groundwater flow regime so the groundwater will flow through the PRB rather than be altered by it and thus escape treatment.

The combination of GeoSierra's probabilistic design methodology coupled with rigorous start-to-finish QA/QC methods serve to provide our clients high confidence that each PRB will perform as expected.

Sam Wells, Chad Givens and Chris Givens Setting Up The Hydraulic Pulse Interference Test

Hydraulic Pulse Interference Test - A Prerequisite for Many PRBs

PRBs must be <u>permeable</u>, yet only GeoSierra employs a foolproof method, the Hydraulic Pulse Interference Test (HPIT), to verify that a PRB has not impeded the groundwater flow regime. A form of the HPIT has been employed by the petroleum industry since the early 1960's to determine the conductivity of oil fields. GeoSierra has adapted the HPIT for pre and post-construction characterization of the site where a PRB is to be installed.

The HPIT is essential to confirm the permeability of an installed PRB, since visually determining whether a PRB is impermeable, due to ineffective construction methods is impossible. This is done by conducting the HPIT <u>before and after</u> placement of the PRB, and the results are then compared immediately to determine if the PRB is of adequate permeability. Alternative tests, such as slug tests or pump tests, are useless for this purpose because of their limitations, which, too frequently, yield inaccurate results.

The HPIT involves a cyclic injection of water into a source well, and then with high precision measurement of the pressure pulse in a neighboring well, detailed hydraulic characterization between wells can be made. The HPIT is highly sensitive to the hydrogeological properties between the source well and receiver wells. The transient nature of the test, involving the time delay and attenuation of the hydraulic pulse, enables the formation's complete hydraulic properties to be computed, including complete transmissivity and storativity. Additional advantages of the HPIT are the short duration of the test, the high resolution and directional characterization data obtained, and the lack of any investigation derived waste.

To maximize the HPIT's resolution, a small section of the injector source well is isolated by packers and the flow into the source injector well is rate controlled and set at a constant flow rate depending on the site hydraulic conditions (i.e., ~20 gallons per minute (GPM) for 20 second durations or "pulses").

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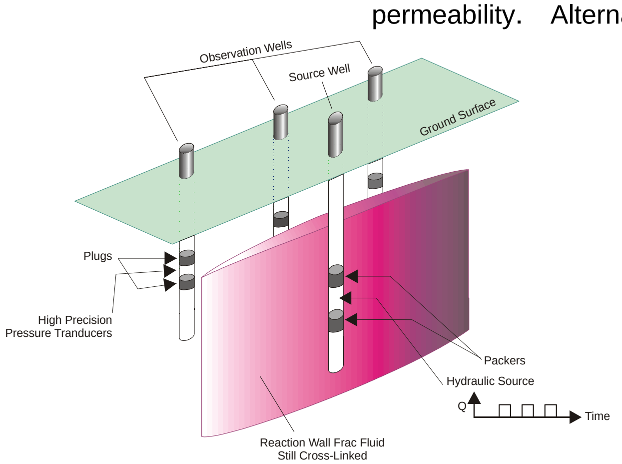

Post Hydraulic Pulse Interference Test

GSA Contract Holder
CONTRACT #GS-10F-0061P

Recent GeoSierra Deep PRB Installations for BP and the D.o.D.

GeoSierra recently completed two PRB installations in California, in addition to the DuPont PRB site installed in 2001 in Oakley, CA.

GeoSierra's first installation of a deep PRB for the Department of Defense (DoD) was completed at the Sierra Army Depot (SIAD) near Herlong, California in April 2003. At this site, the primary contaminant of concern is trichloroethene (TCE) at levels up to 3,000 parts per billion (ppb). The SIAD PRB is 75 feet (ft) long, extends 20 ft vertically from 95 ft below ground surface(bgs) to 115 ft bgs, is 4.5 inches thick, and contains 53 tons of iron filings.

In August 2003, GeoSierra completed a PRB for BP at their former site in Gardena, CA (greater LA). The first phase of the PRB is a source control barrier to treat the highest concentrations of the TCE impacted groundwater. The PRB at this site is 100 ft long, extends 82 ft vertically from 18 ft bgs to 100 ft bgs, is 4.5 inches thick, and contains 250 tons of iron filings.

It's noteworthy that all three of these California PRBs are deeper than 100 ft bgs.

Loading ZVI Into Dustless Hopper for Injection

GeoSierra Deep PRB Installation Video Now Available

We've just completed a video series spanning the 12 years since our discovery that it is possible to create and control a single vertical fracture in the subsurface. The video includes footage of our current, 3rd generation technology taken at the BP site, an explanation of all of our specialized equipment and tooling, our specialized QA/QC tools and processes, and detailed animations showing how the frac/injection is done in the subsurface.

We've been perfecting our trenchless technology for a long time as evidenced by closing footage shot during field experiments back in 1992 and 1993 involving the use of our first generation frac initiation tools and injection of bentonite cement walls. You'll get to see early footage where we were digging the fractures up to determine the vertical and lateral extent of the frac injection.

At your request we would be glad to send you the video. If you would like one, please send an email with your mailing address to jortman@geosierra.com. Please indicate which video format your PC requires**,** i.e. DVD, or MPEG?

Shooting Video During Latest Installation

GeoSierra Installation Site Tour Conducted at Gardena, CA Site

GeoSierra recently invited interested parties to visit the installation of a PRB at a depth of 100 ft bgs at an operating industrial facility. Sixty people from the regulatory agencies and private sector attended the tours. Many commented on how remarkably clean they found the site to be and how minimally invasive and disruptive GeoSierra's trenchless construction technology actually is compared to conventional trenched methods.

During the site tours the participants learned about the urban friendly aspects of the trenchless PRB installation technology, how clean and safe it is, observed its agility in navigating around underground utilities, and saw firsthand why it generates less than .005% (1/2 of 1%) of the waste generated by conventional PRB construction methods. Also demonstrated was GeoSierra's patented "Active Resistivity Imaging" technology, which enables the frac injection coordinator to "see" (in real-time) each segment of the PRB as its injected and visually verify it's coalescence with neighboring vertical and lateral segments. The "Active Resistivity Imaging" technology verifies that the PRB is a continuous, completely coalesced iron wall of iron filings in the subsurface, installed according to all specifications.

Sam Wells and Grant Hocking of GeoSierra Conducting Site Tour

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Hydraulic Pulse Interference Test, continued from Page 2. . . .

High precision pressure transducers are located in receiver wells and isolated from receiver borehole storage effects by straddle packers. Thus the pulse is basically a point source and borehole storage effects are eliminated from both the injector and receiver wells. The injector well is pulsed for a set time, shut in for the same time period, and the cycle repeated. The pulse source and receivers can be located at differing depth locations in their respective wells and a detailed image of the site's hydraulic conditions can be determined.

The results of the HPIT are combined with the site hydraulic gradient to provide a highly accurate groundwater flux rate. The flux and porosity of the to be installed PRB are then combined with the groundwater chemistry data, contaminants, daughter concentrations and their half lives, which are derived from a pre-design bench scale groundwater column test, to design the PRB with a high probability that risk reduction objectives for effluent concentrations will be achieved.

A HPIT should be conducted in association with any PRB design and installation, regardless of the installation method. The pre and post PRB installation HPIT is the only accurate means of verifying a PRB has been installed properly and thus will perform as required. If millions of dollars are to be spent installing a PRB, the HPIT is the client's best means of holding the installer accountable for its proper installation.

GeoSierra warrants its PRBs will be permeable and won't cause groundwater to divert and escape treatment. The HPIT verifies permeability of the PRB and validates the warranty.

About GeoSierra...

GeoSierra, a privately owned company, is based in Atlanta, GA. GeoSierra concentrates its expertise and technology focus on projects and services involving solutions for remediation of contaminated groundwater and soil. While we are capable of providing turnkey completion of projects from investigation, testing, design and construction, we frequently participate in teaming arrangements with other solution providers. We are always open to such teaming arrangements and recognize the added value such arrangements can often bring to a project. Application of GeoSierra's specialized deep PRB technologies have been instrumental in helping to successfully modify a number of soil and groundwater records of decisions (RODs). The results, in each case, have been substantial life cycle cost savings and accelerated cleanup times.