Utilization of Innovative Methods to Design and Install a ZVI-PRB Using Vertical Inclusion Propagation to Intercept a Chlorinated Plume

Deborah L. Schnell, P.E. (dschnell@geosierraenv.com) and
Peter J. Palko, P.E., CHMM, LSRP (GeoSierra Environmental, Inc., Medford, NJ, USA)
John Santacroce (AECOM, Latham, NY, USA)

Background/Objectives. In April 2016, the United States Army Corp of Engineers (USACE) issued a bid solicitation to qualified permeable reactive barrier (PRB) installation firms with capabilities to install continuous PRBs to depths exceeding 100 feet. GeoSierra teamed up with AECOM to provide a solution that complied with the needs of the bid solicitation that was designed by Stone Associates on behalf of the USACE. To cutoff migration of a dissolved phase trichloroethene (TCE) plume traveling towards downgradient receptors, a zero-valent iron permeable reactive barrier (ZVI-PRB) was designed and installed utilizing a patented vertical inclusion propagation (VIP) process between the depths of 65 and 110 feet below ground surface (bgs) at a site in Glenville, New York. Initial site data suggested the ZVI-PRB required a nominal 3-inch pure iron thickness to treat the TCE to remedial goals. To validate site hydrogeologic data, four compliance monitoring well pairs were installed along the azimuth of the ZVI-PRB and a baseline evaluation of hydrogeologic characteristics of the aquifer was conducted using hydraulic pulse interference test (HPIT). HPIT results confirmed a groundwater flow velocity in the upper 15 feet of the target depth to be an order of magnitude faster than the lower 30 feet, resulting in a change in design thickness (3 to 6 inches) for a portion of the ZVI-PRB height following consultation with our design partner, AECOM, based on their groundwater expertise and knowledge of the area.

Approach/Activities. The performance of ZVI-PRBs is well documented in literature and can provide for an immediate, long-term, passive remedy to protect downgradient receptors. As part of the VIP design, GeoSierra conducted bench column studies and probabilistic design scenarios to determine a confidence level of the reduction of CVOCs. An additional critical component of the design is to ensure adequate residence time within the PRB based on intrinsic groundwater flow velocities. HPIT provides a highly sensitive evaluation of the aquifer characteristics compared to industry standard testing methods, resulting in a calculated hydraulic conductivity and storativity. Following completion of the HPIT, the thickness of the ZVI-PRB was altered to a nominal 6-inch within the upper gravel and cobble zone and remained 3-inch thickness in the lower sand zone to provide necessary residence times. The spacing of the injection points was also revised to 12 feet versus the conventional 15 feet to ensure minimal loss of ZVI to the highly conductive cobble zone.

The ZVI-PRB was installed through 189 patented expansion casings installed at seventy-seven (77) locations. Installation of one to three vertical expansion casings per borehole allowed the PRB to be constructed from approximately 65 to 110 feet bgs along 650 linear feet (LF) of the PRB and 65 to 80 feet bgs along the remaining 250 LF. During the injection of the 1,150-tons of ZVI, significant gel QA/QC parameters including viscosity, pH, temperature, and resistivity were monitored per gel batch and a custom active resistivity geophysical imaging system using 31 customized receivers parallel to the PRB was used to track the progress of the inclusions and the coalescence of the ZVI between adjacent points and depths. At the end of the installation, GeoSierra again conducted HPIT to confirm minimal changes in groundwater flow velocity.

Results/Lessons Learned. Although the PRB was successfully installed per the design parameters established to the depths and locations desired, there were some challenges

experienced along the way involving active resistivity imaging near overhead high voltage electrical lines running parallel to the azimuth, which required alternative ground installation methods and perceptive data capturing relative to weather and the time of day. A discussion of these challenges as well as the stepwise process of the design methodology and implementation will be presented. Additionally, local high-volume groundwater extraction wells used by an industrial facility continue to be monitored to evaluate possible effects on the site flow net during various periods although the PRB's placement and location was installed to be protection of downgradient surface water bodies.