NANO-SCALE ZVI-ENHANCED REDUCTIVE DECHLORINATION OF PCE DNAPL IN FRACTURED BEDROCK

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Background

In late 2003, ARCADIS performed a nano-scale ZVI remediation project at a fractured bedrock site (confidential client) located is the Northeast United State. At this site, ZVI was intended as an abiotic enhancement of anaerobic enhanced bioremediation application in the source area of a tetrachloroethene (PCE) plume where dense non-aqueous phase liquids (DNAPL) are known to be present. The impacted aquifer consists of low-permeability siltsones and shales, with groundwater flow occurring along horizontal bedding fractures.

To date, the full-scale application of anaerobic bioremediation technology at this has been very successful in the reductive dechlorination of PCE. However, due to the presence of DNAPL in the source area ZVI was selected as a means to further optimize the degradation process and shorten the overall lifespan of the groundwater remediation effort.

Following a program of pre-pilot testing, three five-foot fracture intervals were targeted for the in-situ application of PolyMetallix^{tm} ZVI particles. The injection program consisted of a borehole fracture conditioning step followed by field preparation and injection of the ZVI suspension. The ZVI suspension was injected during one field event and included the delivery of 100 pounds of ZVI (dry weight basis) delivered in 529 gallons of suspension solution.

Results

Following application of the ZVI particles a series of groundwater monitoring events were performed for the injection well and surrounding monitoring wells to assess the performance of the ZVI approach. These analytical results suggest abiotic processes dominated in the area where the ZVI was distributed overcoming the biological treatment reactions ongoing prior to ZVI application. These results were evidenced by the following; shifting relative concentrations of CVOCs (more PCE, less degradation intermediates), a shift in pH, and highly elevated dissolved hydrogen concentrations.

Other observations that were made in connection with the ZVI injection include:

- Concentrations of PCE in the treatment zone were not reduced to a great degree. This is likely attributable to the high source mass (DNAPL) in the treatment zone.

However, the ZVI treatment did results in the reduction of concentration of lesser chlorinated ethene compounds present.

- An order of magnitude difference in free chloride concentrations indicates an additional 2,500 mg of PCE is being degraded per liter of water flowing through the treatment area (approximate).
- Injection of the ZVI had no apparent affect on formation permeability or groundwater flow patterns.
- The reactivity of the injected ZVI was evident by the dramatic increase in dissolved hydrogen concentrations to levels four orders of magnitude above background.
- Microbial activity related to the delivery of organic carbon is enhancing the solubility of the target CVOCs, making more mass accessible for both microbial dechlorination and reaction with the ZVI.
- The effective radius of the ZVI injection was limited, but sufficient for at least limited peripheral effects to be observed in monitoring wells as far as 45 feet from the injection well.

At this time, ARCADIS continues to collect long-term post treatment groundwater data to further assess performance and evaluate additional application of ZVI for treatment at this Site.