Permeable Reactive Transects for Treatment of Hexavalent Chromium in Varied Geology

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Background/Objectives. Environmental practitioners have been hesitant to recommend treatment protocols based upon the injection of viscous slurries. This incertitude is based upon a misconception that installation of these types of injectates may adversely affect the subsurface hydrological conditions in the targeted formation or are unfeasible for installation (e.g., promote pore clogging; reduced distribution). We were able to successfully demonstrate a method to install a viscous slurry in both a silty sand unit and a glacial till unit at significant depth without the use of soil mixing or hydraulic fracturing, for the treatment of hexavalent chromium in soil and groundwater at a confidential site in New Jersey. The injectate was installed in multiple transects to form passive zones which allow site groundwater to flow through and react with the injectate, reducing hexavalent chromium to trivalent chromium, and makes performance monitoring simple using existing monitoring wells and transect zone-specific piezometers. For vadose zone soils, bench testing was conducted as proof of concept and confirmatory soil samples were taken post-installation. The selection of this type of amendment and installation was preferred for this phase of the project when compared to other alternatives, such as excavation and direct mixing.

Approach/Activities. Site geology precluded traditional direct push technology (DPT) from being utilized for injection, due to dense silty sands, gravels, and glacial till at depth. An innovative proprietary injection process (GeoTAP™) was used to access targeted depths. GeoTAP injection locations were installed using roto-sonic drilling technology, which allowed for expeditious advancement of borings. At each location, after logging and photographing the soil to target depth, the evacuated borehole was backfilled with a specific hydrated bentonite mix. Injectate loading (lbs/gal) was calculated by the product manufacturer based on a bench study using actual site soil and groundwater in advance of field work. GeoTAP spacing was determined by the transect-specific groundwater flux and injectate loadings and ranged from 15 to 30 feet apart (injection centers) – very wide spacing for a slurry injectate. This application is a contemporary modification to more conventional permeable reactive barrier (PRB) application.

Injections were performed in a top-down fashion with 300-gal of slurry (FerroBlack-H®) being injected every 3 feet vertically within each targeted borehole section. Installation was completed using a unique high flow/high-energy injection system capable of varying flow rates (up to 280 gpm) and sustaining injection pressures (up to 2,600 psig). A total of 34,000 gallons of injectate was installed across 2,340 linear ft (lf) during four weeks of injection activities. Injectate distribution was assessed, using existing monitoring wells and newly installed piezometers at the specific target depth of the injected transect. The influence of the injectate was monitored by measuring changes in pH and ORP in proximal monitoring wells and the reaction was fundamentally immediate, as evidenced in groundwater parameters and samples.

Results/Lessons Learned. The initial design for these reactive transects was based on previous experience injecting similarly viscous slurries at depths reaching 170 ft-bgs, so there was some history to support the designed injection spacing and shot volume. However, some design assumptions had not been previously attempted, for example using a decreased flow rate and/or lower pressures to affect injectate distribution using the high-energy Triplex system. Through varied initial injection efforts, it was determined that the optimal operating rage in this geologic setting and with this high-solids, fine-particulate injectate was 50 to 200 psig and 300-gallon shots per injection interval. However, at shallower depths and to control daylighting, similar distribution was achieved at 50 to 80 psig and conducting sequential shots of 200 and 100 gallons. These optimized approaches provided the greatest, effective distribution of injectate at the larger injection point centers – creating injection overlap and building the reactive transect.