Permeable Reactive Transects for Treatment of Hexavalent Chromium in Varied Geology

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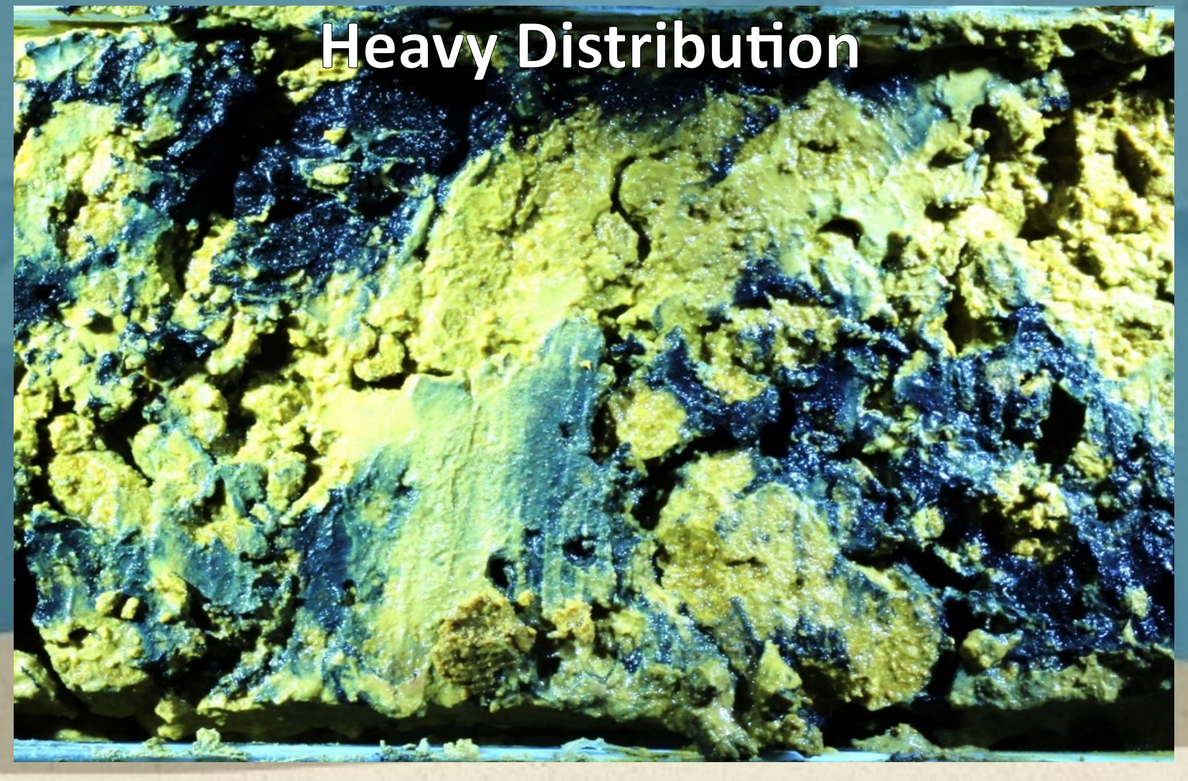
Access Problems

It has been difficult or impossible to access various geologic zones, such as till, weathered rock, saprolite, and urban fill at remediation sites using commonly available drilling equipment, such as direct push technologies (DPT). However, by using a sequential combination of drilling methods and an engineered backfill process, GeoTAP™ allows environmental practitioners to target and treat these zones using DPT injection with various reactants and reagents.

The GeoTAP method has now been successfully demonstrated on numerous projects and in varied geologic settings across the United States to treat groundwater impacted with petroleum hydrocarbons (PAHs), chlorinated solvents (CVOCs), and heavy metals.

Here, as an example, a viscous slurry was installed in a silty-sand unit and a glacial till unit at significant depth without the use of soil mixing or hydraulic fracturing. This transect application was a contemporary modification to conventional source and permeable reactive barrier (PRB) options. This installation was preferred for this phase of the project when compared to other alternatives, such as excavation and direct mixing.


Heavy Distribution


Horizontal Seams

Design

A viscous slurry reactant (FerroBlack®, a mackinawite structured iron sulfide) was chosen for this site due to the investigation results. The remedial design characterization (RDC), which is an evaluation of soil and groundwater mass and mass flux, indicated a significant mass of reactant was needed to install reactive transects in the phreatic zone. This was predicated on a minimum 30 year lifespan for these reactive transects- approximately the time it would take the most upgradient, impacted groundwater to reach the transect and react with the injectate. This RDC process was critical to calculating the necessary loadings to install at each transect and at specific verticals intervals within those transects.

Historically, 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). A high-energy installation method, which is also used with GeoTAP, is well suited for this application. This approach can install slurries via radial mixing, seam insertion, or fracturing.


Vertical Seams

Approach

Site geology precluded traditional DPT from being utilized for injection, due to dense silty sands, gravels, and glacial till at depth. An innovative proprietary drilling and injection process (GeoTAP™) was used to access targeted depths. This process also provided a complete vertical soil profile, which allowed the determination of succinct top and bottom injection spans for each injection point within the transect, i.e. no under– or over-shooting the injection intervals as the geologic interval varied laterally across each transect.

Injection locations were installed using roto-sonic ("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 in lifts with an engineered hydrated bentonite blend to prepare the borehole for high-energy injections. Sonic drilling and backfill activities took five weeks to complete and were conducted with a four-week lead time over injection activities.

Depending on the location and product loading, injection point spacing was determined by the transect-specific groundwater flux (from the RDC) and injectate slurry loadings. The spacing of injection points was typically 15 to 30 feet apart depending on product loading.

To deliver injectate, a DPT rig was used to drive 2.25" injection rods, fitted with a geology-specific injection tip, through the bentonite column to the targeted injection interval (typically 30 to 70 ft-bgs). Installation was completed using a custom high-flow/high-energy Triplex injection system capable of flow rates up to 280 gpm and sustaining injection pressures as high as 2,000 psig.

Lessons Learned

The initial design was based on previous experience injecting viscous slurries at depths reaching up to 170 ft-bgs. At this site, we attempted a decreased flow rate and/or lower pressures, while still affecting injectate distribution, which was successful.

A total of ~34,600 gal of FerroBlack was installed across five transects, totalling 2,340 linear ft (lf), during four week of injection activities. Injectate distribution was assessed by placing transducers in existing monitoring wells and piezometers, and by monitoring changes in groundwater geochemistry. Colorimetric evaluation was also simple, as the FerroBlack product is a dark gray; groundwater samples showed visual influence as further reference of product distribution. Using these groundwater monitoring techniques, field emplacement of material was affirmed successful in creating the transect design. Currently, groundwater monitoring continues at the site to monitor performance.

In the end, it was determined that the optimal operating rage of this system with the injectate was 50 to 200 psig and 300-gallon shots per injection interval. However, at shallower depths and to control daylighting, especially in areas with utilities or former environmental construction disturbance, similar distribution could be affected at 50 to 80 psig by conducting separate,