CASCADE CASE STUDY

Site of Former Dry Cleaners with Pneumatic Enhancement of Bedrock for Successful Cascade Chemistries Amendment Injection

PROJECT: Former Dry Cleaners with Contaminated Bedrock

LOCATION: New Jersey

SERVICE: In Situ Injection, Colloidal iZVI™, Fracturing

CONTAMINANTS: Vinyl Chloride (VC), Dichloroethylene (Cis-DCE), Trichloroethylene (TCE) and Tetrachloroethylene (PCE)

CHALLENGE

Lingering Contamination in Business and Residential Area with Potential Structural and Surface Impacts

The site of a former dry cleaners in New Jersey is today an active business and residential area. The site was contaminated with chlorinated volatile organic compounds (CVOCs) and volatile organic compounds (VOCs), initially treated with injection in 2012. This led to a steady decline in contaminant, but the decline had recently flatlined. The client wanted to rid the site of the last of the lingering contamination. The specific primary contaminants were vinyl chloride (VC) and Dichloroethylene (Cis-DCE); secondary contaminants were trichloroethylene (TCE) and tetrachloroethylene (PCE).

The formation at the site was a weathered shale bedrock that is part of the Passaic Formation found in New Jersey, New York, and Pennsylvania. The depth to groundwater was approximately 10 to 15 feet bgs (below ground surface) and a residential well was located behind the property.

Pneumatic enhancement was performed to enhance the radius of influence by increasing the bulk permeability of the target zone. The target treatment zone (TTZ) was both near and under buildings in active use, including a donut shop. These buildings were within 15 feet of the client's designated pneumatic enhancement points, creating the potential for structural impacts. A structural analysis was required to perform pneumatic enhancement within 15 ft of the on site structures.

SOLUTION

Structural Analysis, Pneumatic Enhancements, and the Right Amendment

Before pneumatic enhancement began in the alleyway between buildings and the surrounding area, Cascade planned to conduct a structural analysis to determine the potential impacts that the pneumatic enhancement process might have on the structural integrity of the buildings.

Cascade proposed to drill several injection points, and to complete pneumatic enhancement at each point through discrete three-foot vertical treatment intervals with the application of nitrogen gas for several seconds that would increase the bulk permeability of the formation and increase the radius of influence of amendment injection.

After the Cascade team completed the pneumatic enhancement event, they would then mix and inject the amendment. The proposal was to inject Colloidal iZVI™ from Cascade Chemistries, a colloidal (5 um) injectable zero valent iron. VCs/DCEs are traditionally more difficult to treat with smaller surface areas of micro-scale ZVI (~90 micron). Colloidal iZVI's particle size would achieve a larger target radius of influence (ROI) of 20 feet with less pressure, which is key when working near sensitive structures and under buildings. Colloidal iZVI is more reactive than ZVI and would reduce the VCs/DCEs. Colloidal iZVI offers high persistence and a pre-blended suspension crafted to eliminate field issues such as ignition or clumping. Through processes known as reductive dichlorination, contaminants are degraded upon contact with Colloidal iZVI.

PROJECT EXECUTION

Careful Preparation and Monitoring Enabled Successful Execution

The Cascade team performed a site walk focused on the structures within the work area to determine their means and materials of construction, take specific measurements, and note any pre-existing damage, both cosmetic and structural. Using the data collected from the site as well as existing structural drawings, they modeled the tolerance of the individual structural components of the buildings to determine their capacity for movement. The resulting report detailed the findings of the modeling and analysis and included guidelines on safe application of pneumatic enhancement when operating near onsite buildings.

To address the other challenge presented by this location, the team also leveraged their experience at previous sites with similar depths of treatment and geology to model the anticipated surface heave. During the injections, the crew used survey equipment to monitor for the maximum amount of surface heave and the post-injection resting position (residual heave).

To create the injection points, Cascade drilled 4.25-inch hollow stem augers (HSA) to the top of the rock. Open-rock injection points were advanced via four-inch air-hammer and air rotary drilling techniques. Injection points were drilled to total depth (TD) plus five feet to accommodate the lower packer. Once drilling was complete, the rig lowered a packer injection assembly into the four-inch borehole, with two packers above and one packer below a 360-degree injection nozzle. Once the tooling string reached TD, the packers were inflated, isolating a discrete three-foot injection interval. Each injection location was addressed in a "bottom-up" approach, with the packers lifted for each interval in order.

Pneumatic enhancement in each three-foot interval was completed with the application of nitrogen gas for 10 – 15 seconds to create and/or enhance existing permeability. The specialized equipment used for this process consisted of a skid-mounted high pressure-high flow control module with a digital data logger to operate, monitor, and record various operational parameters. The control module provided precise control of injection pressures, combined with sufficient flows, to facilitate the increase to bulk permeability.

Once the pneumatic enhancement event was completed in each three-foot vertical interval, the Cascade team mixed the Colloidal iZVI in Cascade's custom-built bulk mixing trailer, which can accommodate batches up to 400 gallons. Cascade hauled in water to use for mixing and injection. The amendment was injected through the packer tooling and applied to each interval sequentially. This method effectively distributed the amendment to the target ROI of 20 feet. Up to 350 gallons of ZVI injectate were emplaced in each three-foot vertical treatment interval.

During each injection event, system operational parameters including down-hole initiation and maintenance pressures at the injection point, pressure influence at surrounding monitoring points, and ground surface deflection at the injection point and at building load points were observed and collected.

Once completed, each injection location was abandoned with Portland cement. The final injection report included the location of each borehole, the volume and depth interval of the solutions applied to each injection location, the collected data for injection flow, gallons per minute, pressure, and volume, and digital output pressure vs. time graphs for the pneumatic enhancement events.

"I was at the site this morning with NJDEP and [the Engineer] for a cap inspection and wanted to let you all know the site looks great!"

CONCLUSION

Experience and Expertise Overcome Challenges and Bring Positive Results

A recent comparison of pre- and post-injection groundwater monitoring results from the site's nine monitoring wells showed a significant reduction in the contaminants of concern and the lasting presence of iron from the Colloidal iZVI as it continues to act on those contaminants.

There is a direct correlation between total dissolved iron concentrations in wells and CVOC reduction. The total dissolved iron represents the distribution achieved during injection and varies depending on the fractures available during pneumatic enhancement and subsequent Colloidal iZVI injected. For one monitoring well, VC was reduced from 46 ug/l to 0.85 ug/l and total dissolved iron concentration was increased from 280 ug/l to 124,000 ug/l. For another well, Cis 1,2 DCE was reduced from 1400 ug/l to 40 ug/l, VC was reduced from 780 ug/l to 25 ug/l and dissolved iron increased from 19.5 ug/l to 42,100 ug/l. For the other wells, Cis 1,2 DCE and VC changes also correlated to the dissolved iron noted in these wells post-injection. The wells will continue to be monitored for up to a year and further reduction in contaminants is expected.

Cascade drew on over 25 years of field experience to analyze and address potential impacts to the structures present within the work area at the site. The team followed their best practices, using experienced injection operators and technicians. The combination of the right experience, equipment, and chemical amendment made this project a success for the client.