

Case Study – Pilot Test of ISCO applied with KAPSDIDS

The overall study objective was to evaluate chemical oxidant distribution and contact utilizing the Kinetically Adjustable Pore Space Dilation Injection Delivery System (KAPSDIDS), designed by Badger Injection Solutions, LLC. The following summarizes the evidence of enhanced subsurface chemical distribution in the pilot test area.

Site Conditions

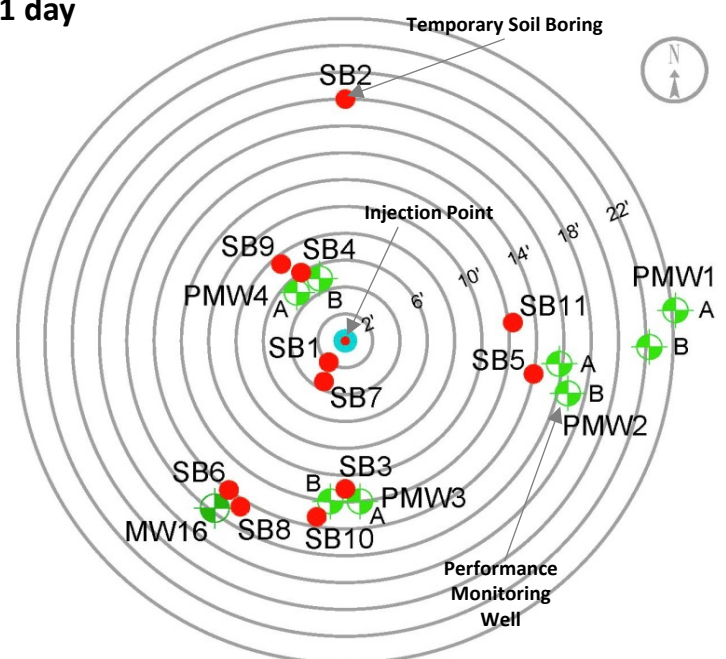
- Pre injection soil contamination – Petroleum impact from 6-12 feet below grade in the study area
- Lithology – unconsolidated Pleistocene glacial deposits comprised mainly of poorly sorted, fine to coarse sands with trace amounts of fine gravel
- Depth to Groundwater – approximately 6.5 feet below grade in an unconfined aquifer having a thickness of approximately 60 feet, and bound at depth by a semi-confining clay unit

Chemical Injection

- 330 lbs of oxidant and an equal mass of iron activator were mixed on-site in a specialized storage tank with potable water to generate 1,500 gallon batches
- The injection rods were installed using a direct-push probe device to the desired injection depth beginning with the deepest depth; 18 feet, 13 feet and 8 feet below grade
- A total of **1,500 gallons** was injected into the subsurface through an injection nozzle attached to the lead direct-push drill rod at an average flow rate of **36 gallons per minute**
- **Onsite injection activities were completed in 1 day**

Performance Monitoring

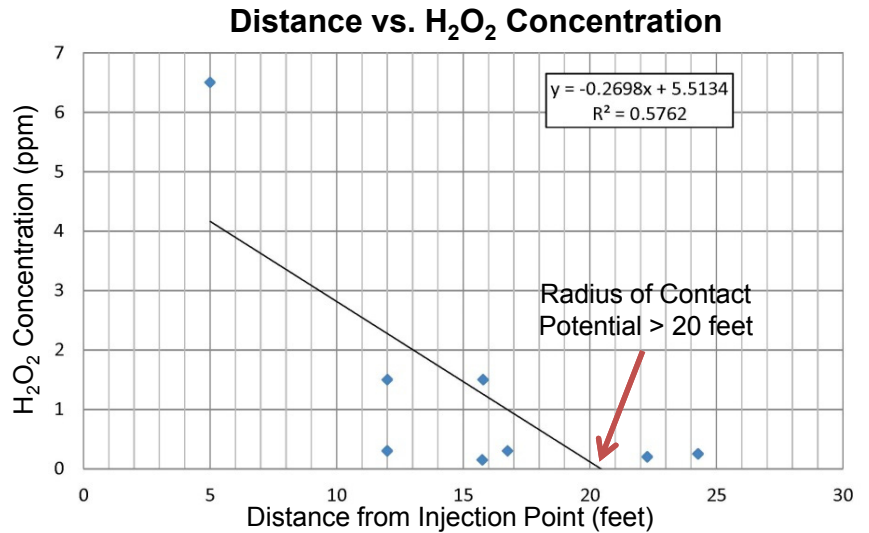
- Performance monitoring wells (PMW) installed at varying depths, distances and bearings from the injection point were monitored for changes in groundwater elevation and H_2O_2 concentrations in groundwater during injection
- Pre and Post injection soil samples were collected from temporary borings (SB) in the pilot test area for field screening and laboratory analysis



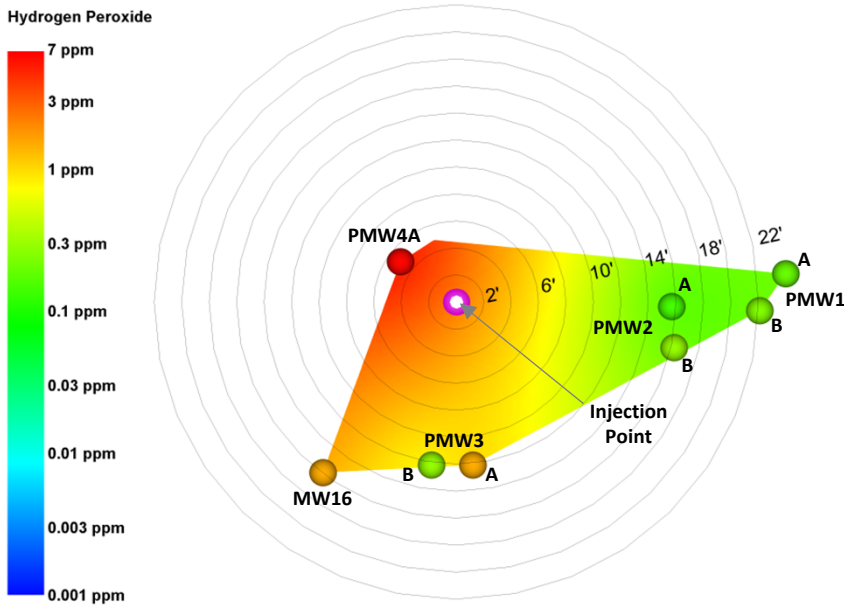
Plan View of Performance Monitoring Network

Field Analyzed Confirmation of Subsurface Chemical Distribution

- Groundwater mounding was observed in all performance monitoring wells
- H₂O₂ concentrations of field screened groundwater were measured in a monitoring well **greater than 20 feet** from the injection point
- Daylighting from seams in the pavement (not from the injection point) **observed 28 feet** from the injection point



Field Screen H₂O₂ Concentrations



Laboratory Evidence of Petroleum Hydrocarbon Mass Reduction

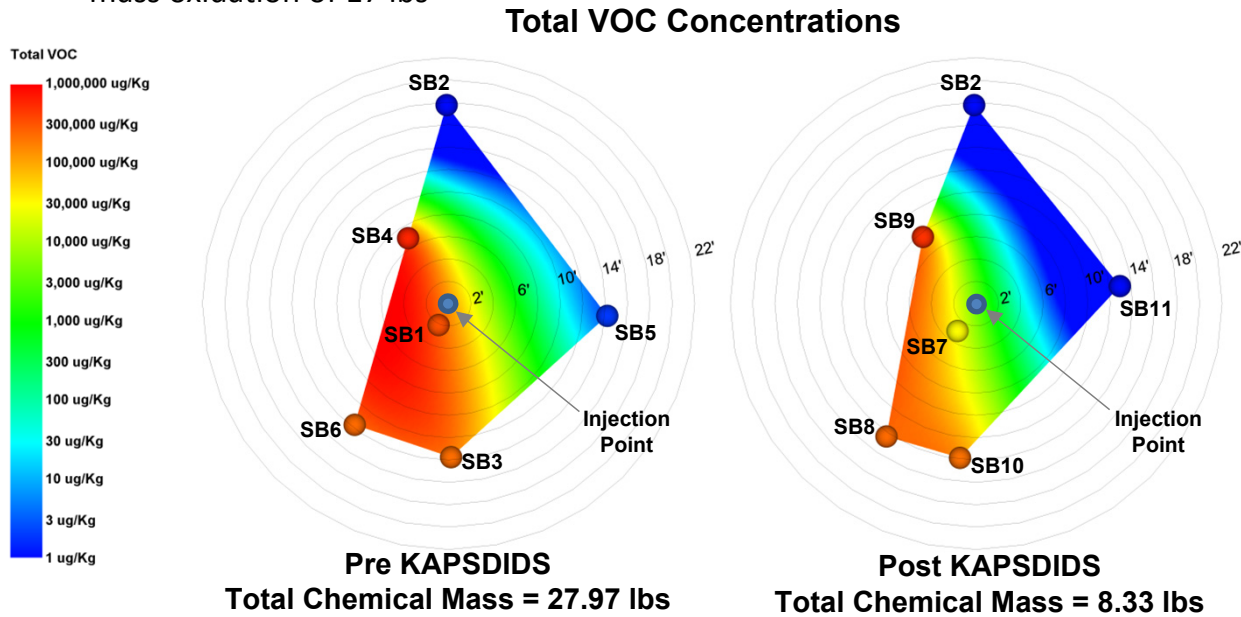
- Average total volatile organic compound (VOC) concentrations **decreased by 42%** in a single 1,500 gallon application
- Most significant decrease of Total VOC concentrations decreased from 315,380 ug/kg at SB-1 to 30,530 ug/kg (SB-7)

Total VOC Analytical Results

| Pre Injection | | Post Injection | | Difference | % Change |
|-------------------|-----------------|-------------------|-----------------|-----------------|-------------|
| Sampling Location | Total VOC ug/kg | Sampling Location | Total VOC ug/kg | | |
| SB-1 | 315,380 | SB-7 | 30,530 | (284,850) | -90% |
| SB-3 | 215,120 | SB-10 | 208,900 | (6,220) | -3% |
| SB-4 | 573,900 | SB-9 | 477,000 | (96,900) | -17% |
| SB-5 | 2 | SB-11 | 0 | (2) | -100% |
| SB-6 | 229,240 | SB-8 | 230,950 | 1,710 | 1% |
| Average | | | | (77,252) | -42% |

Soil Contaminant Mass Reduction Supported by Volumetric Estimates

- Estimated Total VOC mass in the pilot test area was reduced from approximately 28 lbs to 8 lbs
- KAPSDIDS application of the oxidant **EXCEEDED** the oxidant manufacturer’s expectations:
 - Laboratory analysis of the pre and post soil samples indicate that approximately **20 lbs of contaminant mass was oxidized** - given the mass of oxidant, activator and mix volume for this project, the chemical manufacturer theorized a contaminant mass oxidation of 17 lbs



Notes :1) Total VOCs include all reported volatile organics listed in Table 2 of NYSDEC CP-51 (Method 8260)
 2) Mass calculations based on kriged dataset whose area is bound by convex hull (smallest domain which contains all observation points)

KAPSDIDS enables target emplacement of a broad range of in-situ remediation products **faster** and **farther** from the point of injection than any other available method. Aside from reducing the number of injection locations, the core achievement of this technology is the distribution and physical contact between treatment solution and impacted media, resulting in increased remedial effectiveness.

The pilot test summary for this case study is available in its entirety on the website <http://badgerinjectionsolutions.com/news/news.htm> (just look to right side of the page and click on “Yes it will work with the right technology”).

For additional details about the KAPSDIDS, please visit our website (enviro-asmnt.com & badgerinjectionsolutions.com) or contact Environmental Assessment & Remediations (EAR), your Badger Regional Service Provider - Jaime Brown 631.447.6400 ext 153 or JBrown@Enviro-Asmnt.com.