High-Resolution Site Characterization (HRSC) and Three-Dimensional Data Visualization for a Fractured Rock Site: A Path to Streamlined Closure

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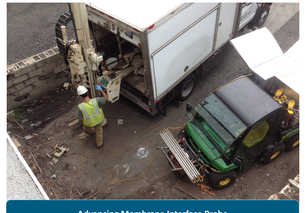
1 INTRODUCTION

Typical Challenges:

- Traditional investigation and data collection methodologies = inadequate data density to overcome site heterogeneity.
- Lack of data density, coupled with data quality issues, and repeated investigations during initial stages of a site's lifecycle resulted in an inaccurate Conceptual Site Model (CSM).

Case Study:

Former specialty chemical manufacturing facility located in Edison, New Jersey with active investigations and remediation from late 1990's. An Interim Remedial Measure (IRM), groundwater recovery and treatment system was operational from 2001 to 2006.



Advancing Membrane Interface Probe

Primary Contaminants of Concern:

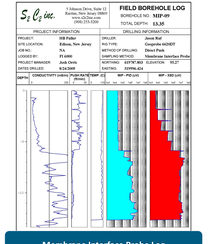
Chlorinated volatile organic compounds (CVOCs); 1,1,1–trichloroethane (TCA), trichloroethylene (TCE) and their respective degradation products.

Geology:

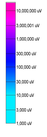
- 0-1 ft bgs. Fill
- 1-6 ft bgs. Weathered Brunswick Shale
- >6 ft bgs. Brunswick Shale

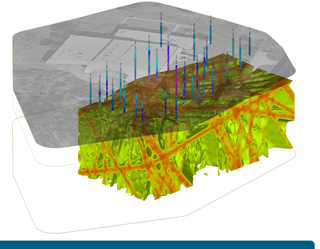
Hydrogeology:

- Perched Groundwater above Bedrock
- Fractured Bedrock Flow



Membrane Interface Probe Log





MIP-XSD Detector Data and Interpreted Bedrock Fracture Model

2 APPROACH

Injection Field Pilot Tests:

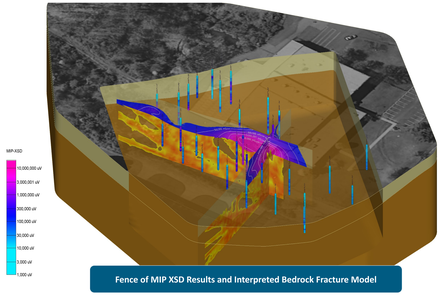
- Emulsified vegetable oil (EVO) and zero-valent iron (ZVI).
- Enhanced injection well design.
- Reduced total number of injection wells.
- Enhanced radius of influence with pneumatic fracturing delivery and contaminant mass treatment.

HRSC Investigation and 3-Dimensional Data Visualization CSM update:

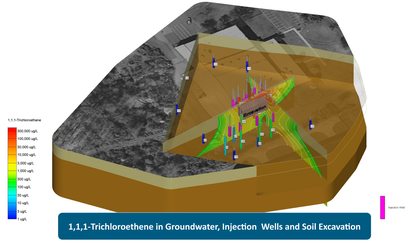
- Membrane Interface Probe (MIP) advanced in overburden to evaluate remaining residual sources and confirm performance of pilot test injections.
- Site data were migrated into an EQuIS database and exported for visualization using C Tech's Mining Visualization Software (MVS).
- Created a geologic model of overburden and fractured bedrock from geophysics data, including an interpreted 3D fracture model.
- 3D kriging was completed for TCA and daughter compounds as well as for MIP-XSD detector data.
- The updated 3D CSM with HRSC data identified a shallow source of TCA at a former loading area.
- Contaminant transport pathways and hydro-geologic systems were confirmed — eliminated a hypothesized second source area.

Additional Remediation and Closure Strategy:

- Excavation of remaining source and placement of **EVO/ZVI** to accelerate treatment of impacted groundwater.
- Soil closure was obtained with complete delineation utilizing both **HRSC** and traditional analytical data sets— residual soil impacts remedied by engineered and institutional controls.
- **Monitored Natural Attenuation (MNA)** as groundwater remedy— reduced well network and reduced monitoring to annual schedule.



Fence of MIP XSD Results and Interpreted Bedrock Fracture Model



1,1,1-Trichloroethene in Groundwater, Injection Wells and Soil Excavation

Injection Array and Manifold

Excavation of Source Material

Click the QR Code or the Weblink to View 3D Data Visualization

https://www.youtube.com/watch?v=DTrB_R6zAEU&feature=youtu.be

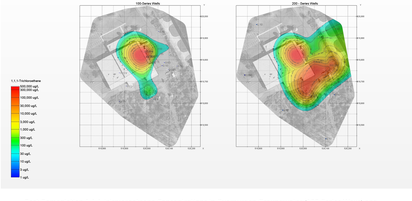
3 RESULTS AND CONCLUSIONS

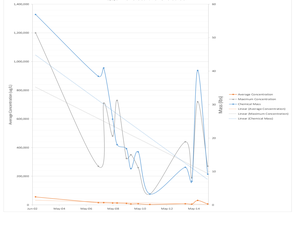
Leveraging Technology — HRSC & Geophysical data in bedrock, MIP data in overburden and historical groundwater data as inputs to a comprehensive **3D CSM** created value by more targeted investigations, successfully designed and reduced number of injection wells, pilot studies, pneumatic injection delivery designs and more precise full-scale remediation implementations. HRSC and development of a 3D CSM enabled a ***"Best-In-Class"*** solution for enhancing insights into the fractured bedrock environment, refined targeted remediation strategy implementation and performance monitoring that facilitated a reduced lifecycle and cost savings.

- **Enabled shutdown (2006) of pump and treat system:**
  - **ANNUAL COST SAVINGS: $180,000, with savings-to-date of ~$2.16M.**
- **3D CSM and HRSC data allowed for more targeted injection design & implementation performance:**
  - **ESTIMATED COST SAVINGS: $300,000.**
- **Enabled a more streamlined regulatory process and transition to MNA strategy with annual groundwater monitoring:**
  - **ESTIMATED COST SAVINGS: $100,000 from monitoring reduction.**
  - **ESTIMATED REDUCTION IN LIFE CYCLE: 10+ years.**

Evaluation of Mass and Chemical Concentration Trends

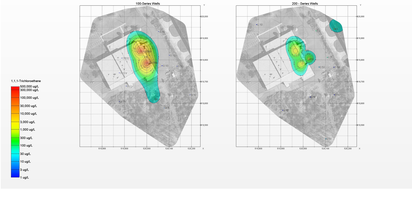
Pre-Remediation 1,1,1-trichloroethane Concentrations in Overburden Groundwater (100-Series Wells) and Bedrock Groundwater (200-Series Wells)

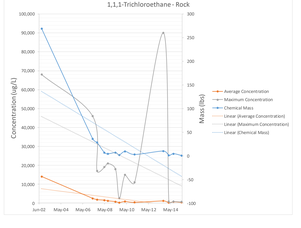




Compound	Overburden (Mass Reduction)
1,1,1-Trichloroethane	84%
1,1-Dichloroethene	85%
Chloroethane	29%

Post-Remediation 1,1,1-trichloroethane Concentrations in Overburden Groundwater (100-Series Wells) and Bedrock Groundwater (200-Series Wells)





Compound	Rock (Mass Reduction)
1,1,1-Trichloroethane	99.8%
1,1-Dichloroethene	99.6%
Chloroethane	35%

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