

SUSTAINABLE HIGH RESOLUTION/REMEDIATION DESIGN CHARACTERIZATION ALLOWS OPTIMIZATION OF FUTURE SOIL AND GROUNDWATER REMEDIATION FOOTPRINT

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BACKGROUND / OBJECTIVES

A large industrial property in Sweden was planned for redevelopment to residential, commercial and school buildings. The site is roughly 70,000 square meters and former industrial activities included use of both chlorinated solvents and possibly other organic compounds (e.g. mineral oils). Historical investigations had initially established the presence of a Trichlorethylene (TCE) source under one of the former production areas, but complete delineation could not be achieved as long as industrial activities were present/active on site.

Local geology consists of silty clay in the upper 6-12 m of the site, followed by different intervals of highly saturated lenses (sandy silt). Silty clay lenses are found present very heterogeneously between each saturated layer. Bedrock is found at different depths ranging from approximately 10 meters below ground level (m bgl) to more than 30 m bgl.

The redeveloper objective was to ensure that a proper high resolution / remedial design effort would guarantee a full delineation of both soil and groundwater contamination to allow for detailed planning of the construction project (10+ residential buildings, schools and commercial buildings), without encountering unexpected sources during the construction phase.

APPROACH / ACTIVITIES

In November 2022, as industrial activities were gradually stopped, the redeveloper decided to perform a full site environmental screening starting from the initially observed source area and then covering the entire site. The investigation efforts led to the completion of approximately 130 Membrane Interphase Probe (MIP) locations (2,500 linear meters covered), collection of 700 soil samples and installation of 60 monitoring wells. All works were completed within the same main mobilization, reducing transportation costs drastically. The use of MIP probing allowed soil coring only where necessary, reducing the amount of soil waste generated. Similarly, groundwater wells installation was tailored according to the MIP results ensuring screens were installed in the correct depths.

The high density/resolution soil and groundwater samples analyzed free of charge at Ejlskov's partners laboratory (RPI Inc.) during the entire project lifetime, allowed the client to save in excess of 750,000 SEK (~75,000 €) in analytical costs.

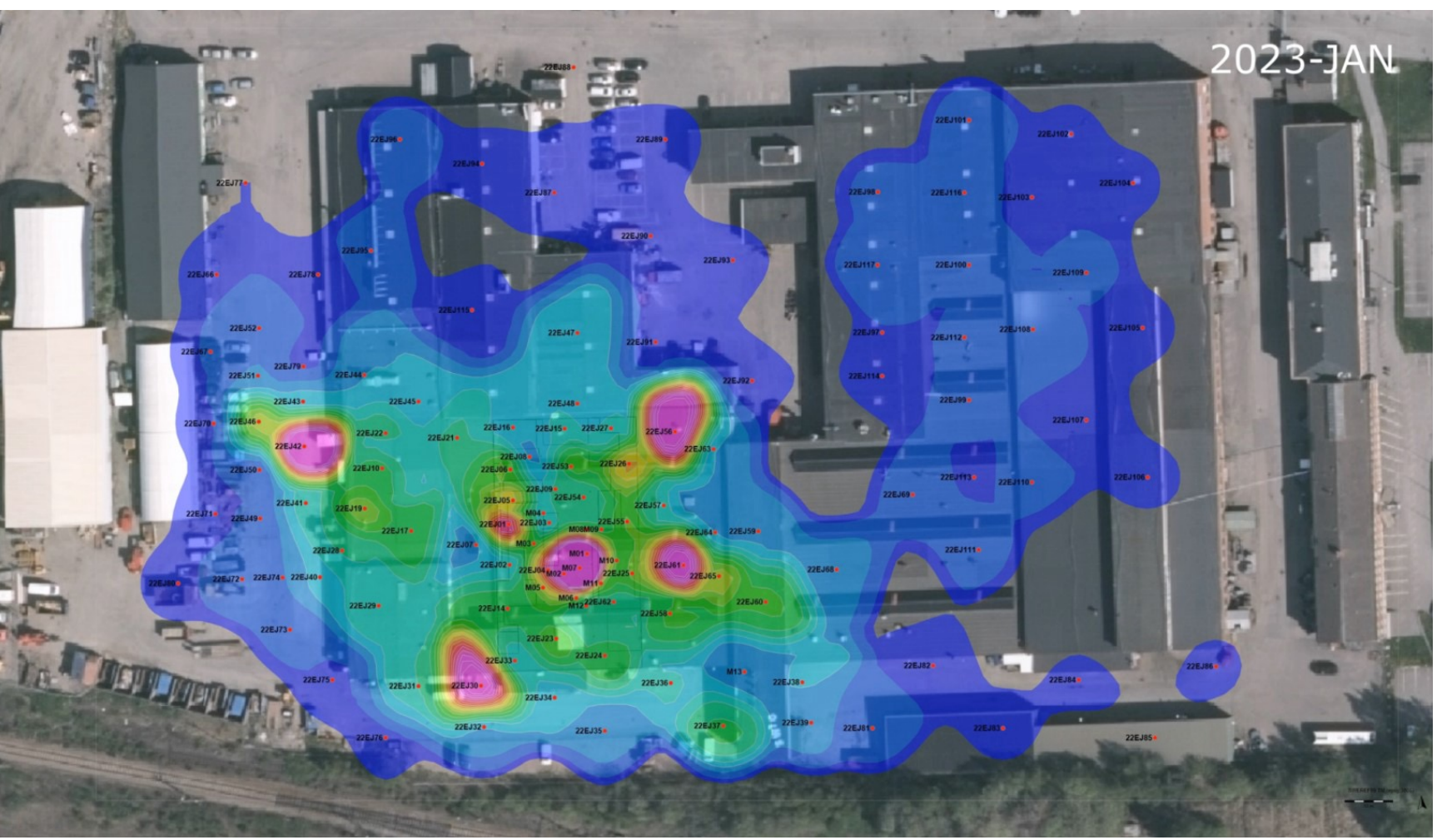
The overall approach allowed the redeveloper to establish with high level of accuracy the amount of soil contaminant mass present on site (including the expected contaminated areas located under future residential or school buildings), evaluate the exact pattern of the spreading of groundwater contamination. A phased in-situ remediation approach was planned to allow the redeveloper to account for disposal of soil only to the depths required for construction of the new building foundations. All remaining contaminated soil would be treated in-situ, while Ejlskov biological in-situ remediation technologies were planned for use within the groundwater bearing unit avoiding any pumping of contaminated water or leaving fixed installations in the ground.

RESULTS / LESSONS LEARNED

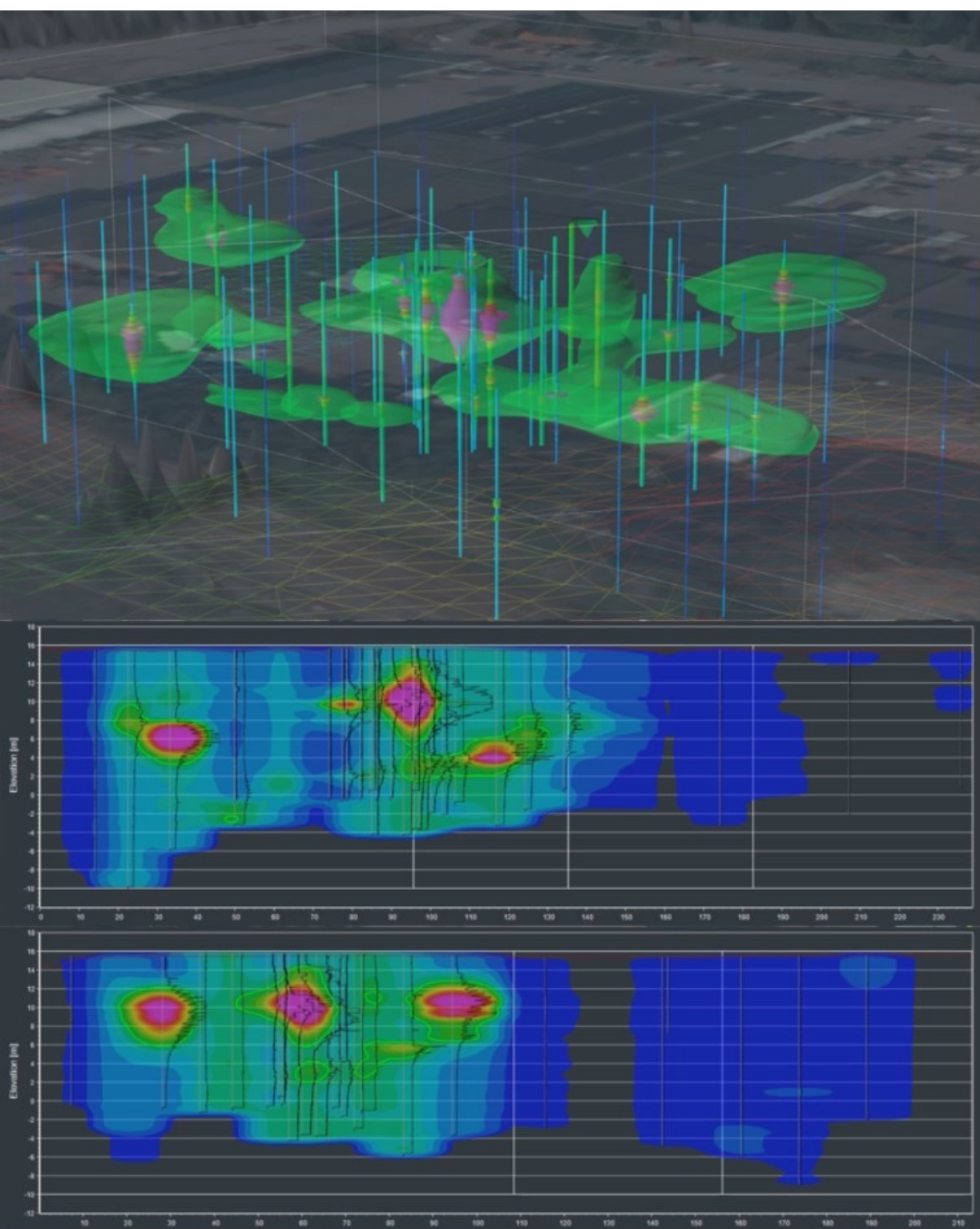
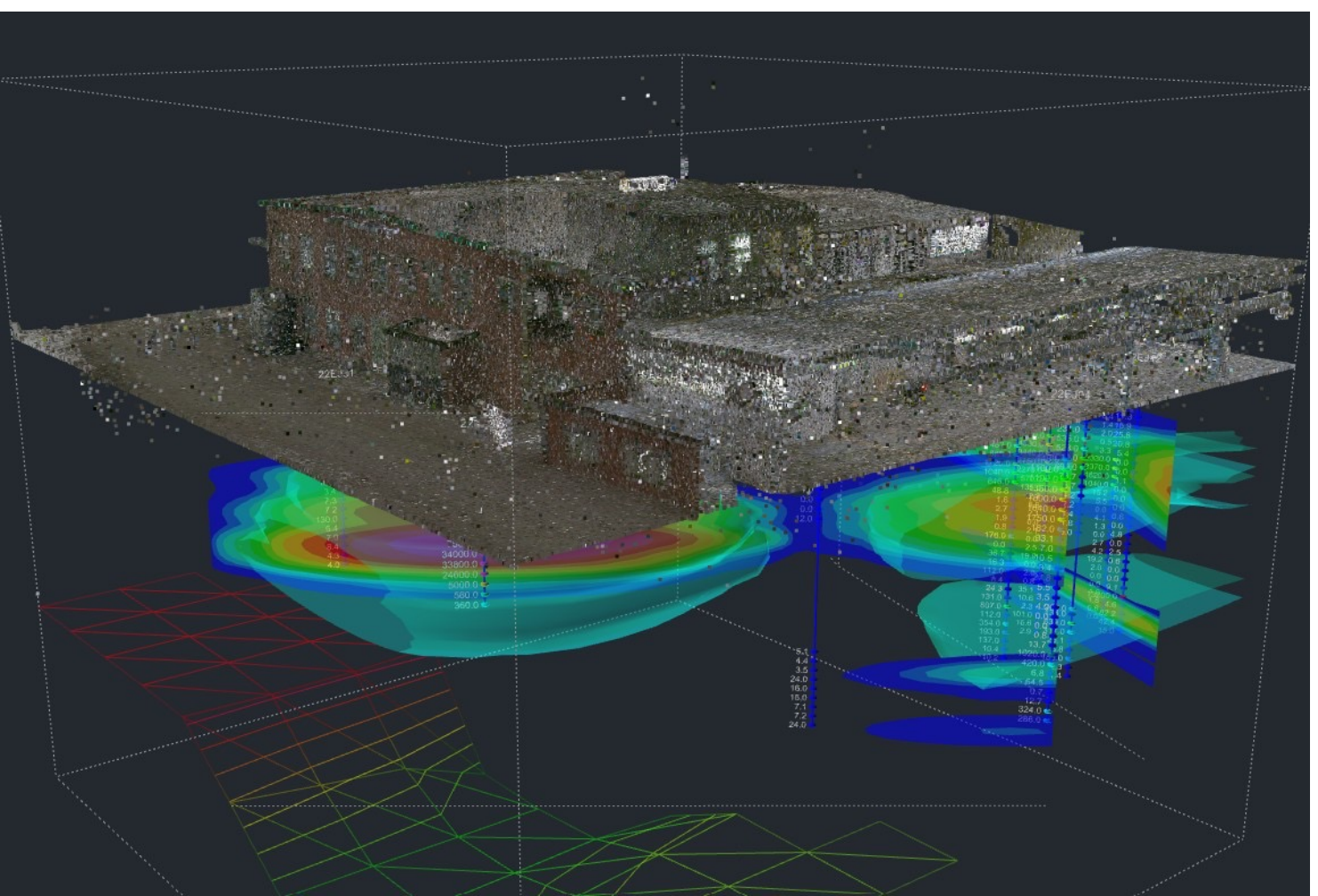
The outcome of the investigation showed that planning of construction activities (both small and large scale) should start at an early stage with a high-resolution site characterization. This type of activity can provide highly valuable information that redevelopers can use more efficiently when planning building locations, use, depths of basements, etc. The benefits (economic, social) can be easily judged as all stakeholders involved in the project can plan more efficiently by having large amount of environmental data at hand, reducing risks of unexpected findings (e.g. new contamination sources) during the construction process, creating new costs, hence increasing the overall project footprint.



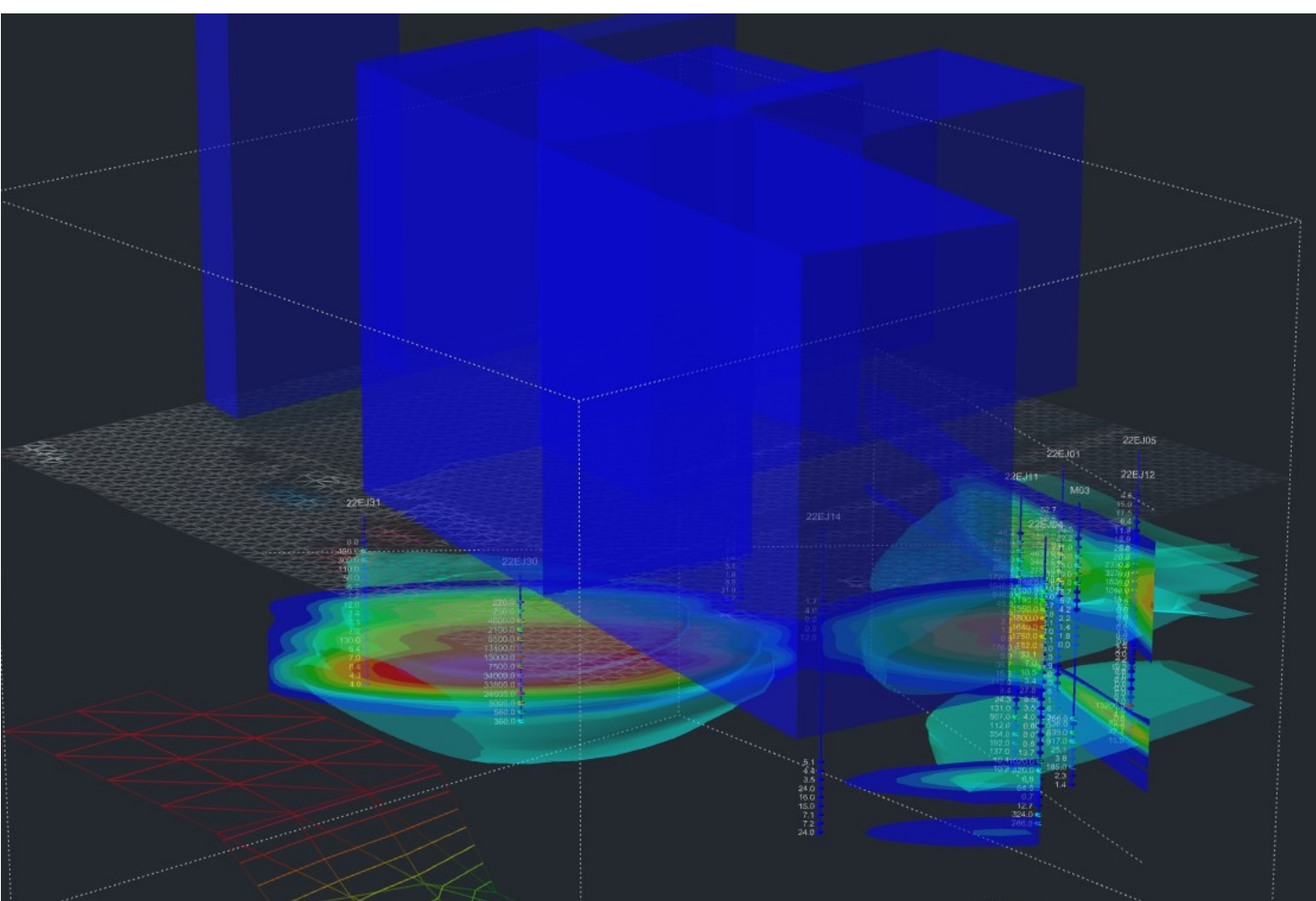
MIP XSD Sensor visualization of preliminary contamination delineation – Single source area



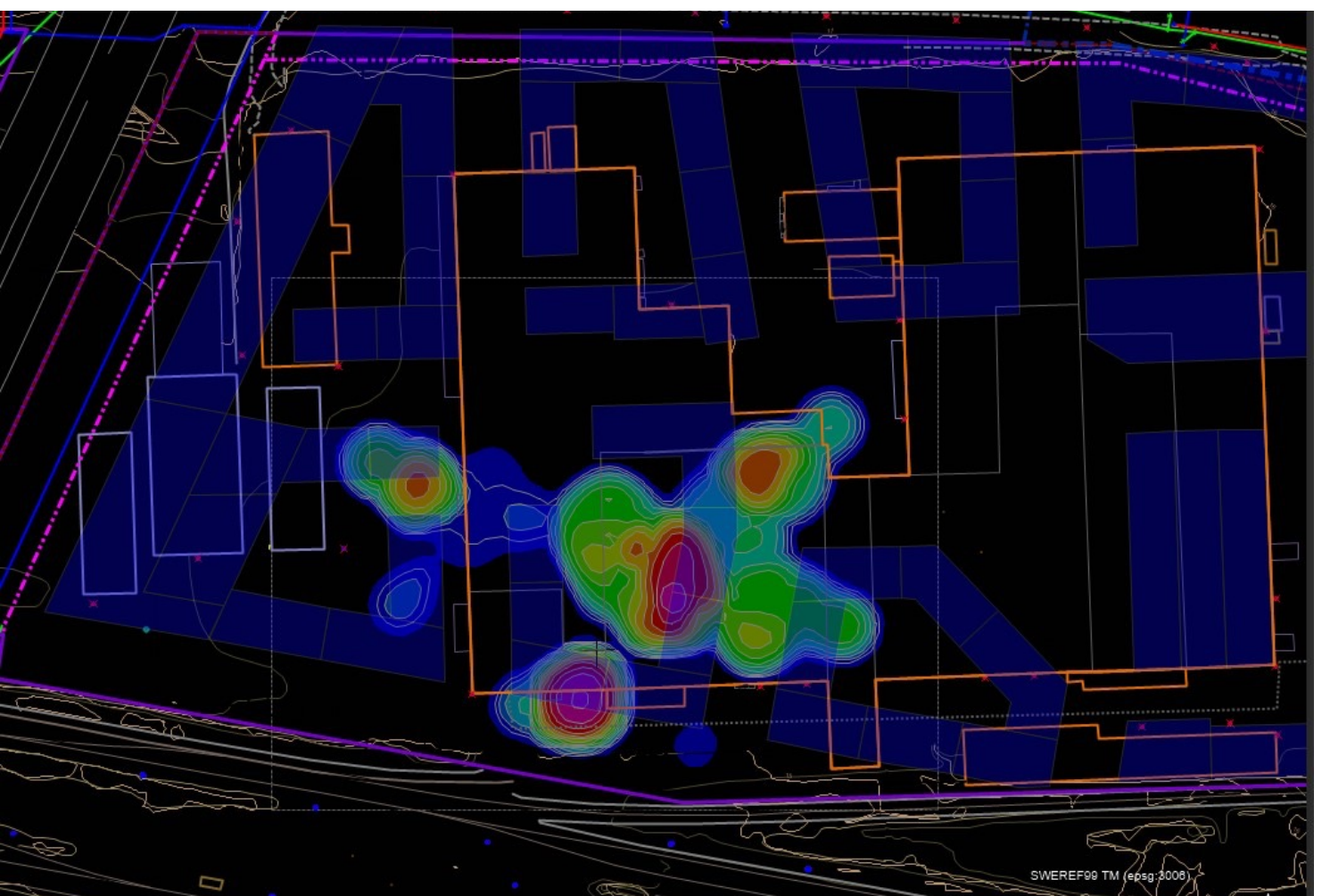
MIP XSD Sensor visualization of overall contamination delineation – multiple sources located



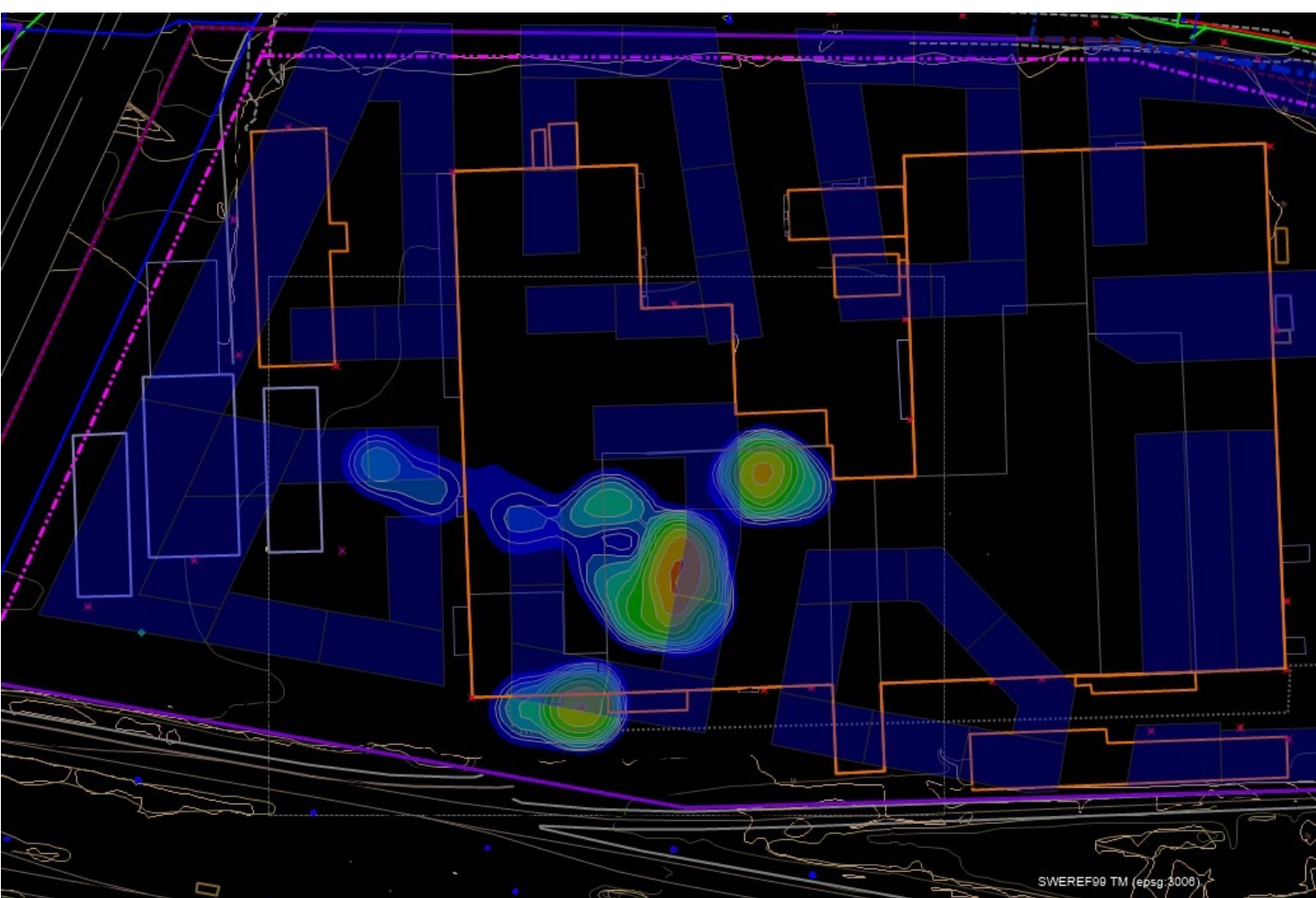
3D Soil Contamination Overview under existing building



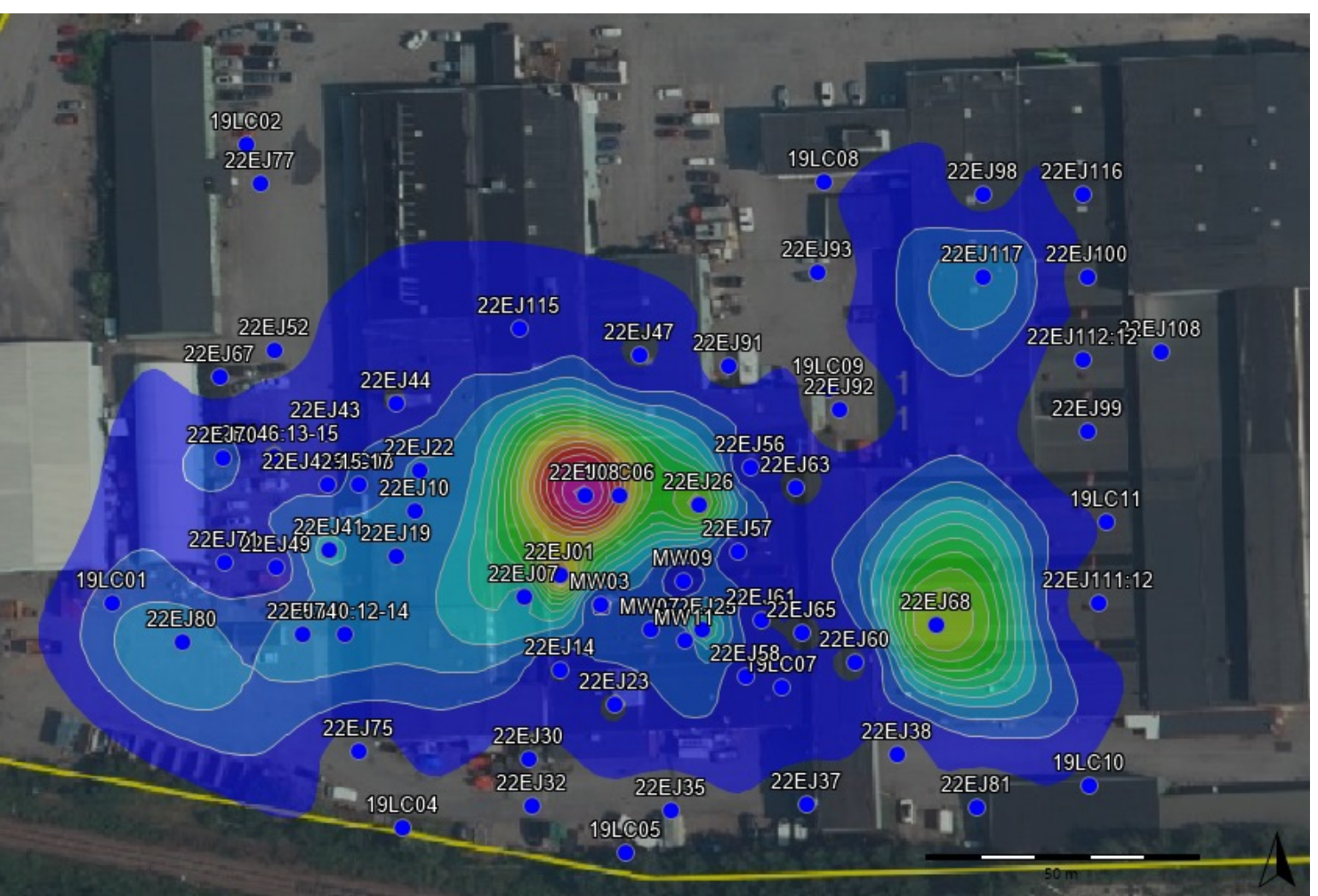
3D Soil Contamination Overview vs. future residential buildings



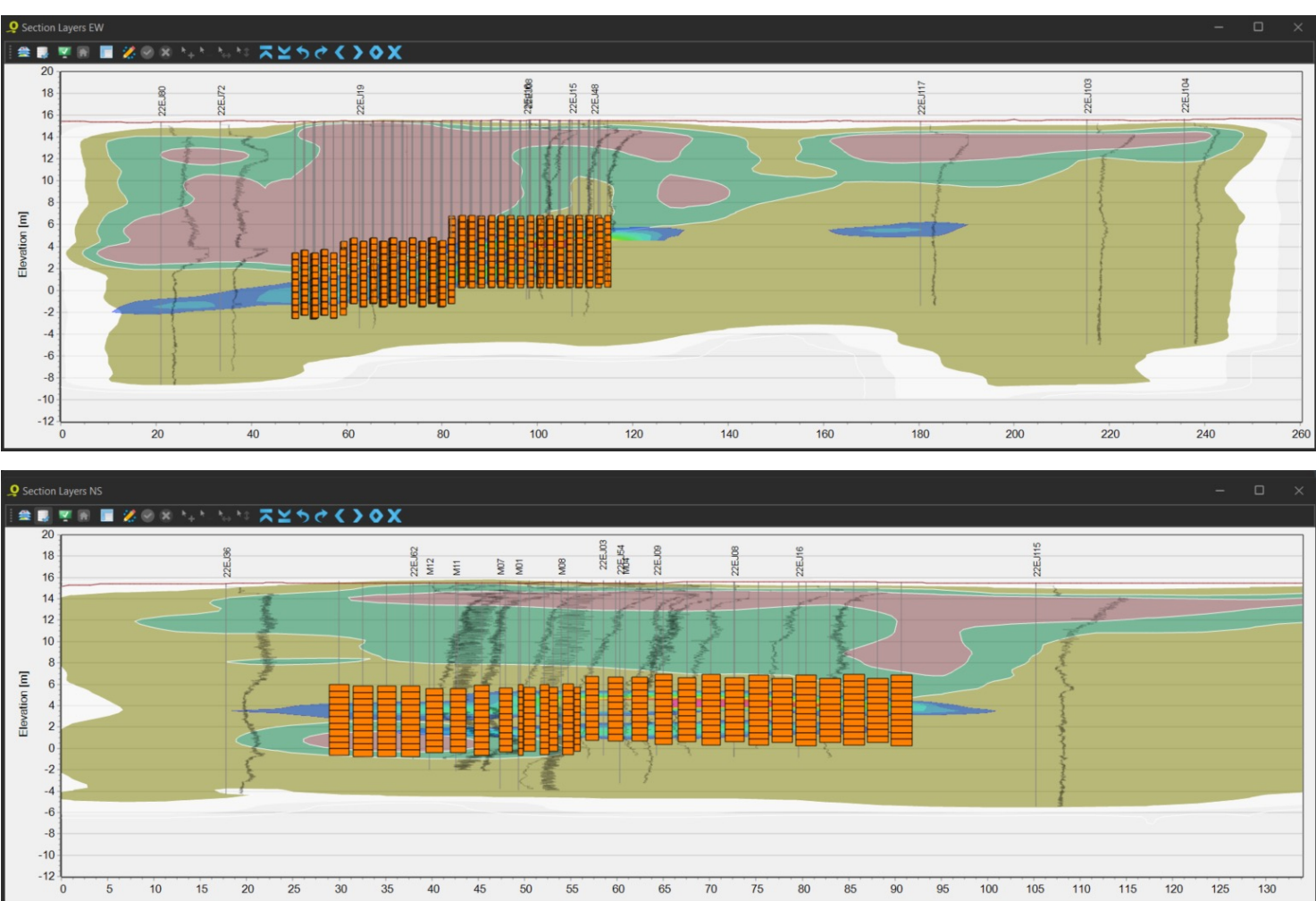
2D Soil Contamination Full Overview – Orange shape building (existing) vs. full blue shapes (new residential buildings)



2D Soil Contamination (0 to 3 m bgl) – Orange shape building (existing) vs. full blue shapes (new residential buildings)



Groundwater contamination overview



Geological overview (X-Sections) including groundwater contamination plume and planned remediation zone

* unit measures not shown due to client request

High-Energy In-Situ Injection of Modified Clay for Sequestration of PFAS

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CETCO®

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Cleaning up the earth

Technology Description

- Modified Clay (MC) product manufactured by CETCO and offered in multiple particle sizes; the smaller particle sizes are used for injection applications and larger particle sizes area used for direct soil mixing and pump and treat applications
- High sorption capacity and not significantly affected by co-contaminants (e.g. petroleum hydrocarbons, TCE), Figure 1
- Can be applied via direct push injection (Figure 2) or via soil mixing (Figure 3)
- Compared to activated carbon, it has a larger sorption capacity and higher sorption kinetics (Figure 4)
- Can be combined with other in-situ technologies to remediate co-contaminants such as petroleum hydrocarbons, chlorinated solvents, and heavy metals

Technology Applications

- AST performed injection field trials of Fluoro-Sorb (Powdered and 100 particle sizes) in 2022 in order to determine injectability and radius of influence (Figures 5-7)
- It was determined that the products injected and distributed similarly to other commercially available solid particle injectates
- First injection field trial (on PFAS contaminated site) completed in 2023 at military base in Canada
- Funnel and gate PRB application completed in 2022 (Figures 3 and 8)
 - Three (3) weight percentages of Fluoro-Sorb (2.5, 5, and 7.5 w/w) were mixed into the treatment calls with clean sand
 - 99+% PFAS reductions at 180 days post mixing

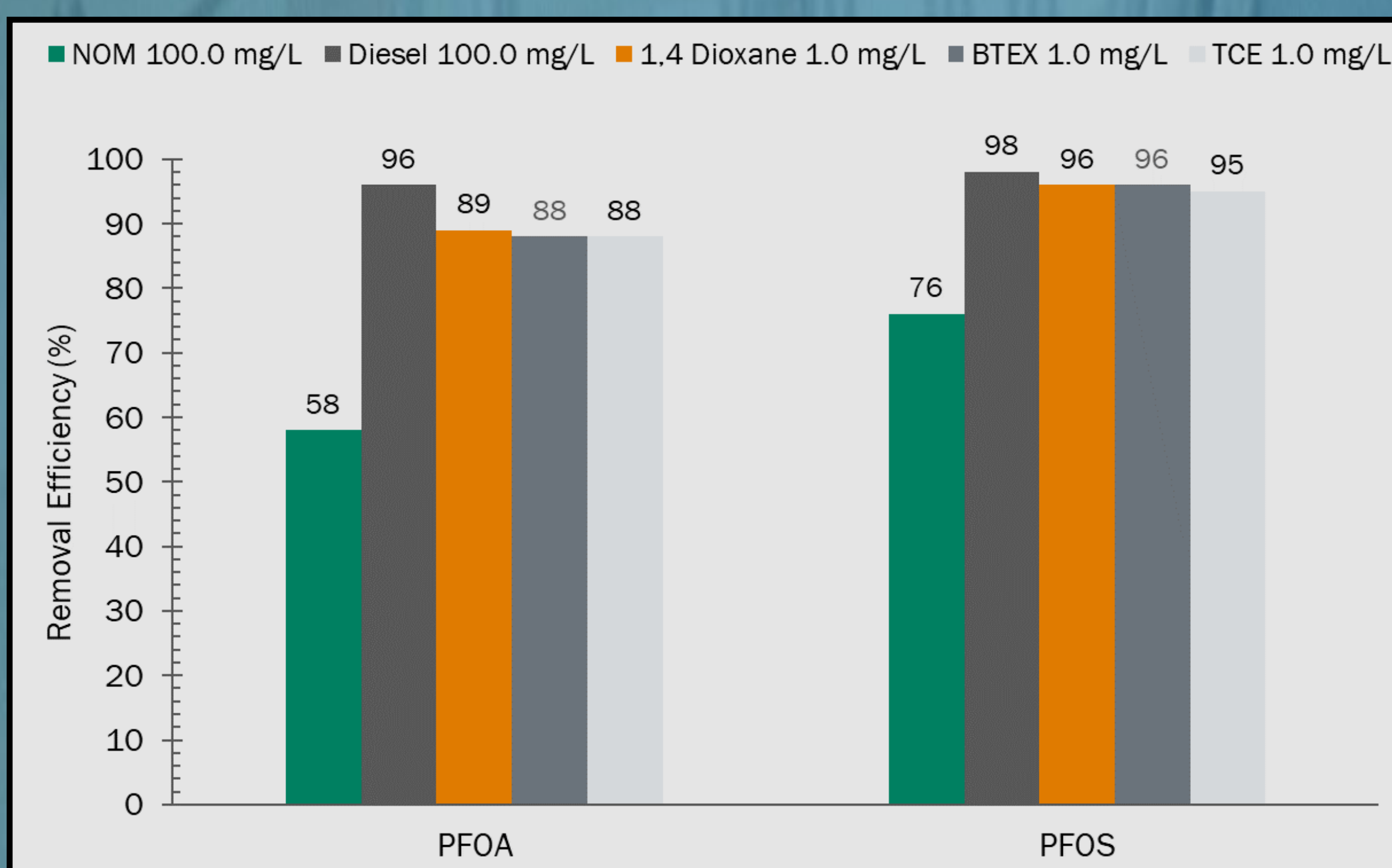


Figure 1. 40 mg Fluoro-Sorb + 500 mL groundwater; 7 day equilibrium

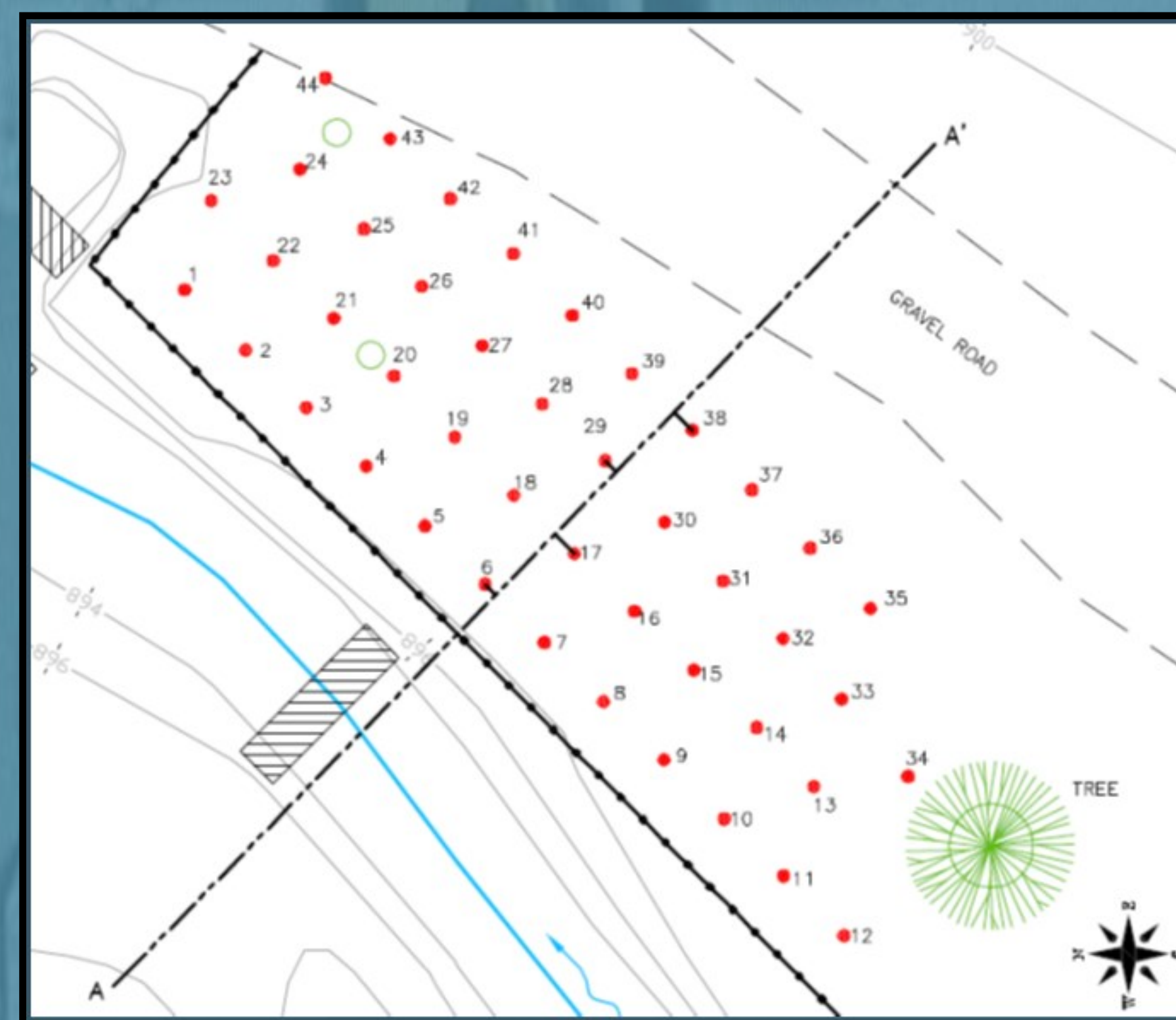


Figure 2. Example of Injected PRB

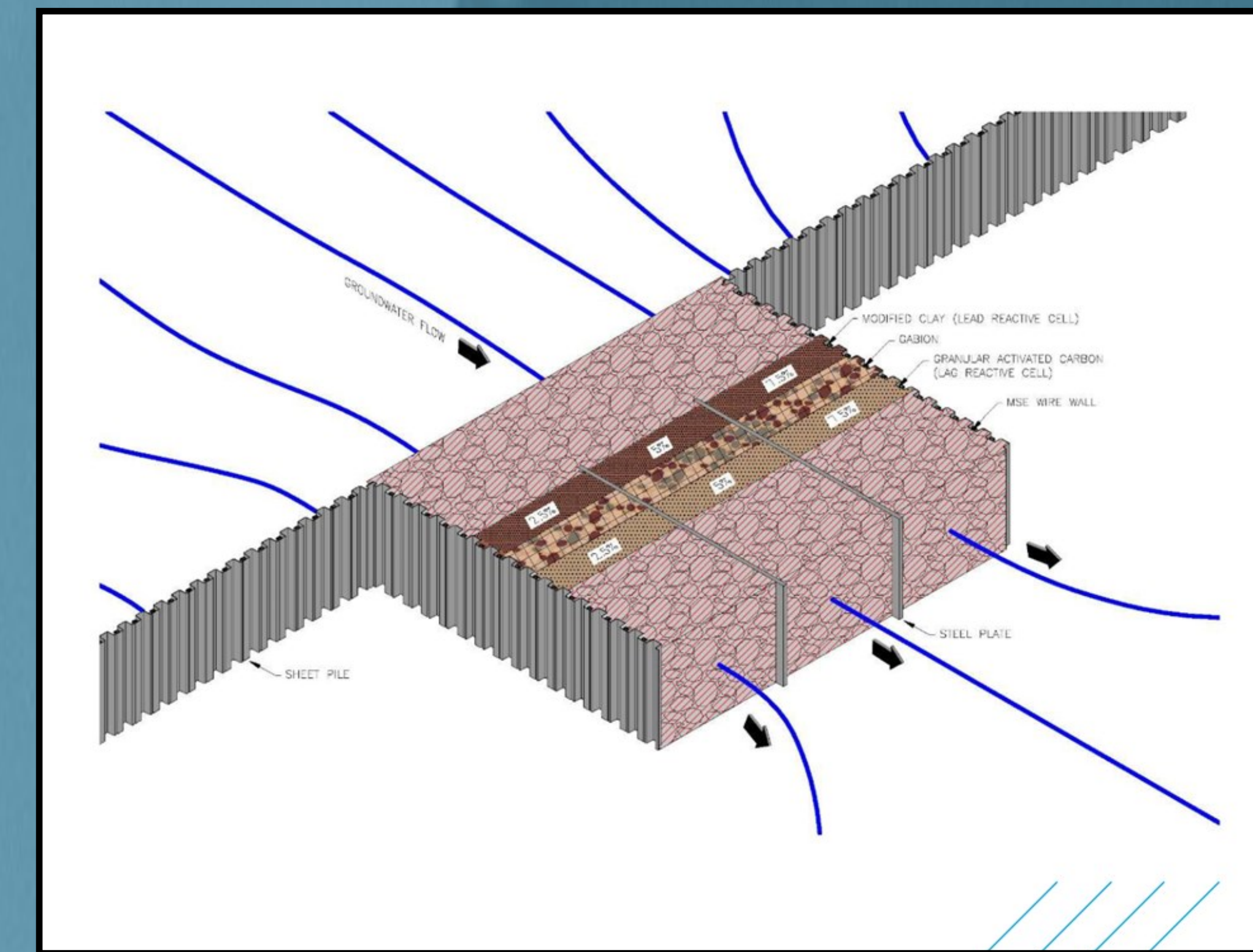


Figure 3. Example of Trenched Funnel and Gate PRB

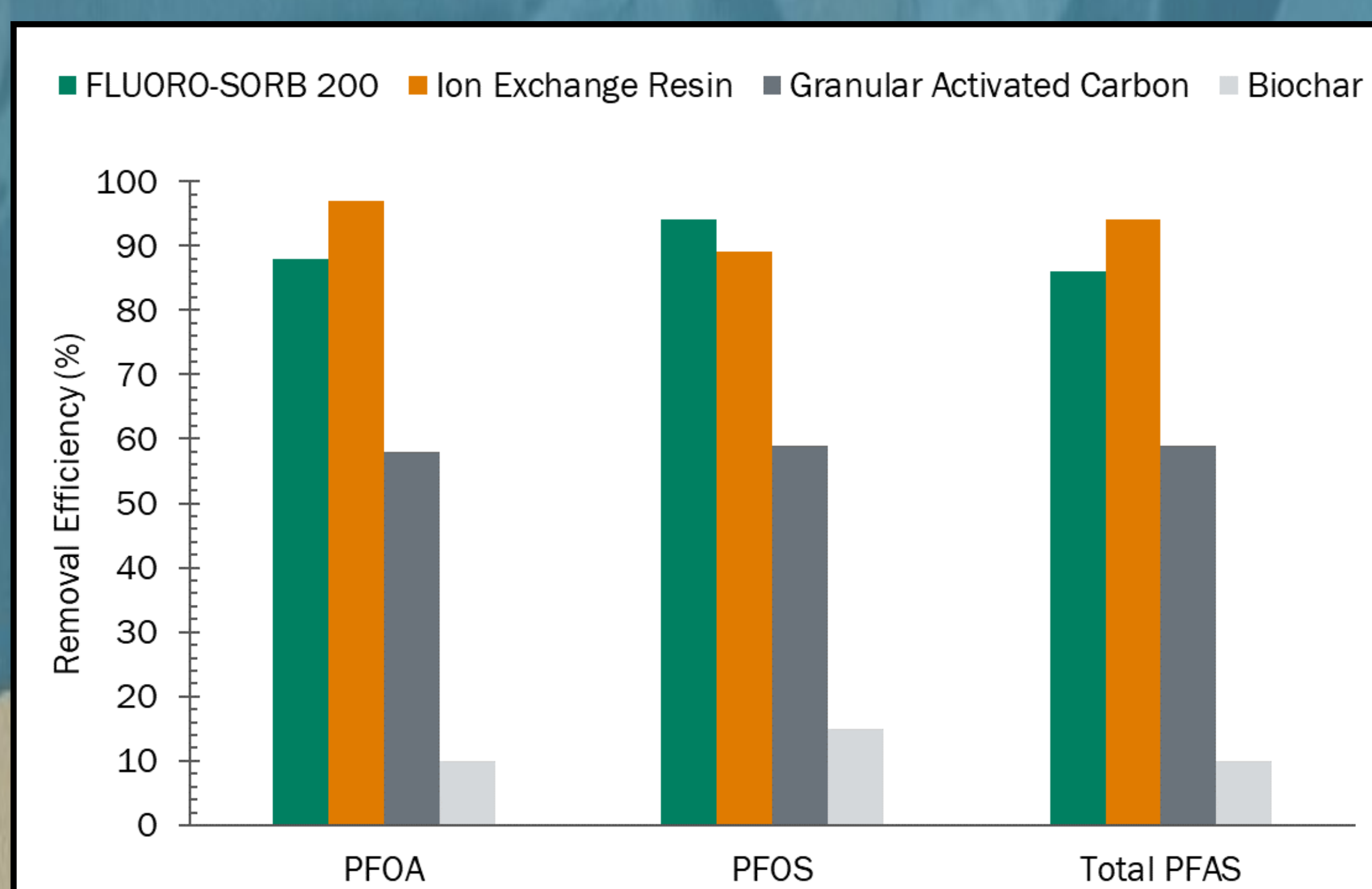


Figure 4. Removal Efficiency for Various Adsorbents



Figures 5-7. Direct Push Injection Field Trials

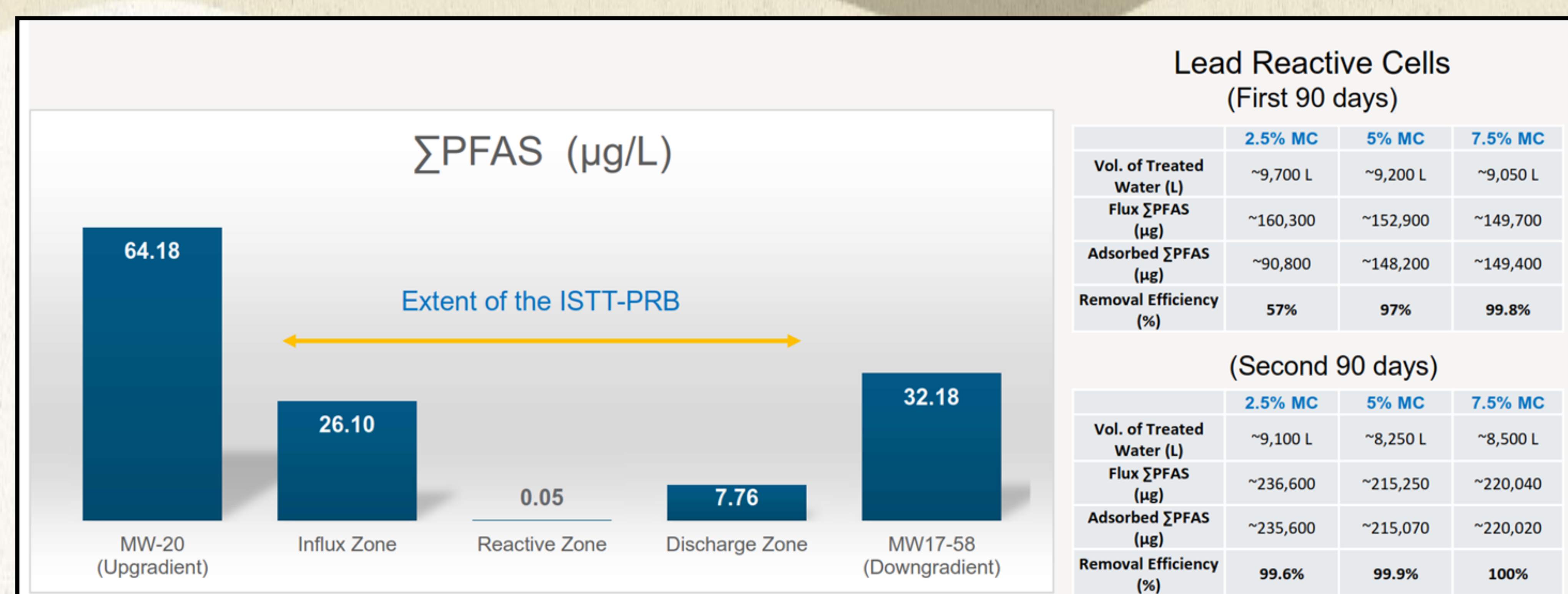


Figure 8. Funnel and Gate PRB Field Data

Installation of A Successful Activated Carbon Based PRB for Petroleum Hydrocarbons and 1,2-DCA

Mike Mazzaresse (mmazzaresse@astenv.com) (AST Environmental, Inc., Golden, CO, USA)

Site Description

- Confidential Site in North America
- The client was purchasing portions of a city block. This Site was the corner lot (Figure 1).
- Former gas station:
 - Operating 50+ years (1930s to 1980s)
 - At least 3 former USTs noted on Fire Insurance Plans
 - Petroleum Hydrocarbon (PHC) contamination
- Site scheduled for re-development

Subsurface Description

- Soil profile: Fill over hard silty-clay till
- Groundwater: 5.2-5.9 m below grade
- Contamination: BTEX, F1, and 1,2-DCA

Remediation Approach

- The first 3 phases of work were performed by others and included the injection of colloidal activated carbon (CAC) and a chemical oxidant.
 - Injection #1: CAC and Oxygen Releasing Material (ORM) injected along 24 meter (m) length in 24 injection points in 3 discrete intervals.
 - Injection #2: CAC and ORM injected along 24 m length in 17 injection points in 1-2 discrete intervals.
 - Injection #3: Chemical oxidant injected in 8 injection points in 2 discrete intervals
- Phase 4 preceded by Remedial Design Characterization (RDC) to better define plume and saturated soil mass
 - Six (6) boreholes with 27 soil samples and 12 groundwater samples collected
- Phase 4 included the application of Powder Activated Carbon, terminal electron acceptors, and hydrocarbon degrading bacteria
 - 81 injection locations with 9 discrete intervals
- Phase 5 included the addition of a dechlorinating culture that is capable of degrading 1,2-DCA

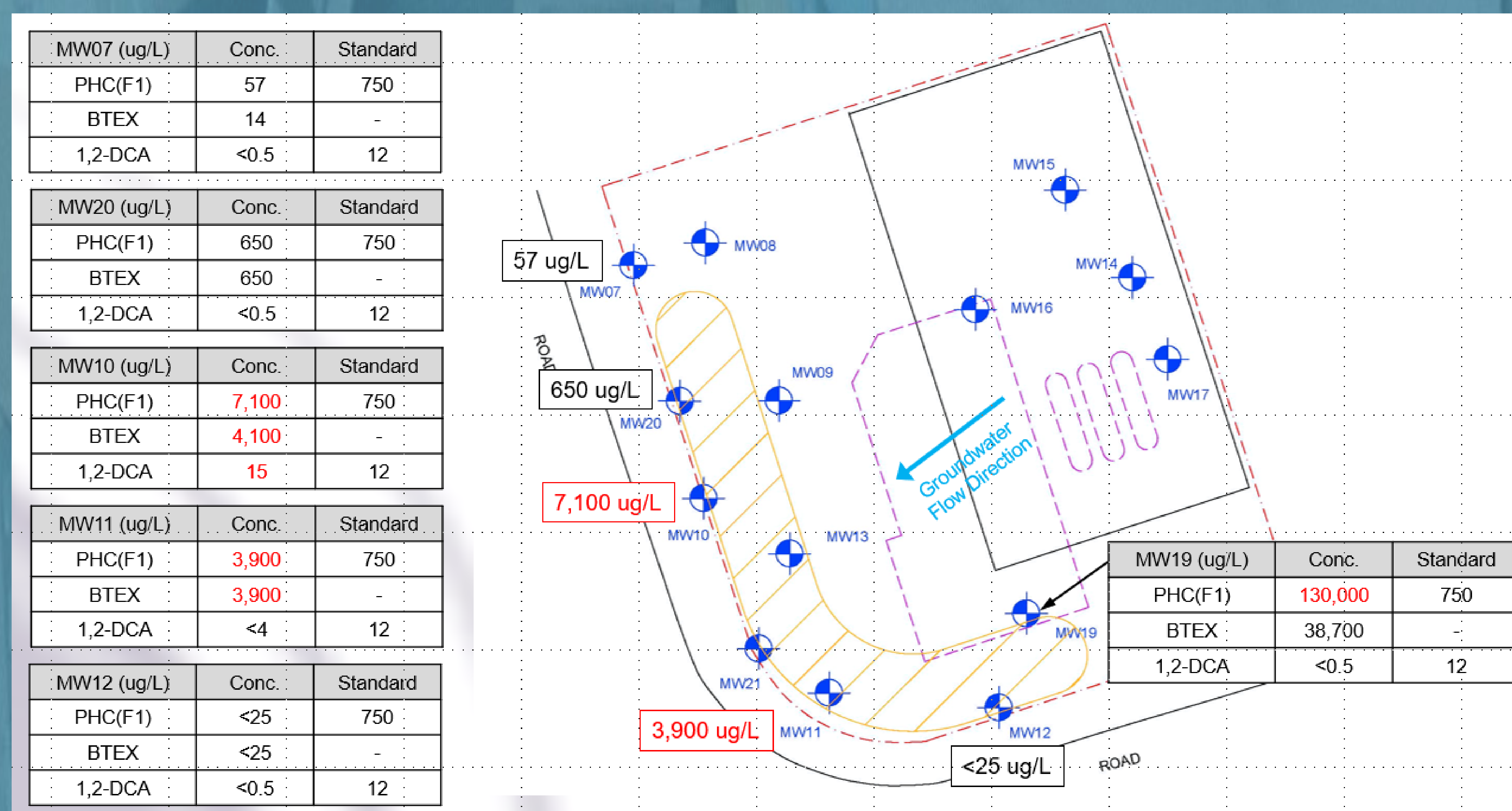


Figure 1. Site Map

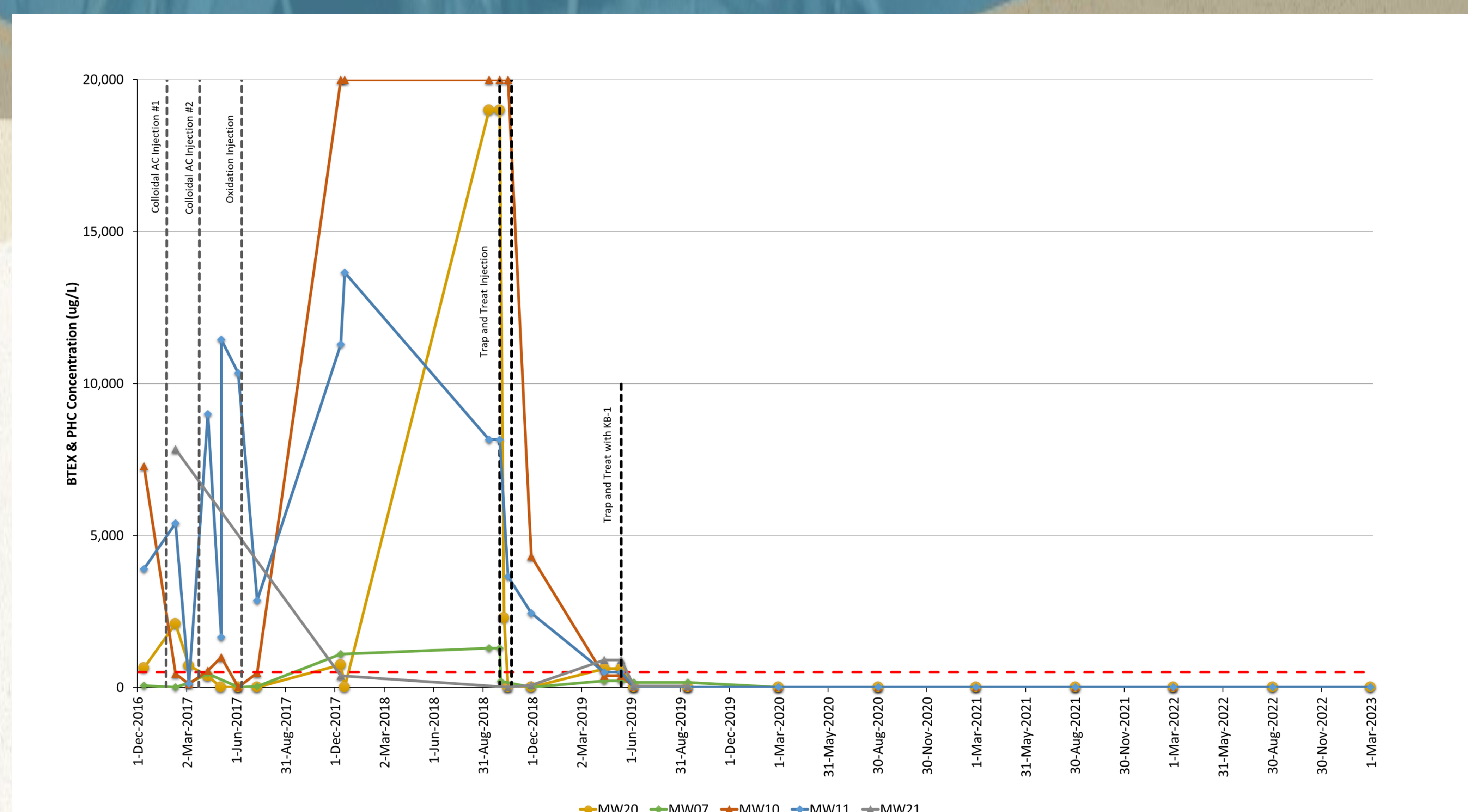


Figure 2. Groundwater Concentrations versus Time