STAR *(In Situ)* Pilot Tests to Treat Refined Petroleum Hydrocarbons

Former Refinery in Michigan

Overview

The subject site is a former refinery in Michigan. A mixture of Gasoline Range Organic (GRO) and Diesel Range Organic (DRO) compounds have impacted a fine to very fine sand aquifer across a smear zone above and below the water table at a depth of approximately 30 feet below ground surface (ft bgs). Two STAR Pre-Design Evaluations (PDEs) were conducted to evaluate Radius of Influence (ROI), combustion front propagation rate, and volatile mass loading. The first PDE was conducted under standard operating conditions while the second test involved the injection of a surrogate fuel (emulsified vegetable oil ([EVO]) to support the combustion of these high volatility compounds (Figure 1).

Pre-Design Evaluation

Self-sustaining smoldering combustion was achieved during both tests; however, during the "standard" STAR combustion test, the treatment zone was limited to an approximate 1 to 2 foot (ft) thickness and a 5 ft ROI as a result of the high volatility and low concentration (relative to smoldering combustion) of the contaminants (Figure 2). Successful injection and combustion of EVO in the "EVO enhanced" test provided a more robust smoldering reaction, resulting in the treatment of an approximate 4-6 ft thick zone with a ROI of 10 ft (Figure 3). Approximately 1,500 kilograms (kg) of petroleum hydrocarbons were removed from the target treatment zone during the EVO enhanced test (10 days) with approximately 20% of that mass destroyed via smoldering combustion. The remaining 1,200 kg of mass was collected and treated at ground surface through a soil vapor extraction (SVE) system installed in the vadose zone. The ratio of mass destroyed versus volatilized (1:4) is significantly different for high volatility petroleum hydrocarbons than for a low volatility compound such as coal tar which typically shows >98% destruction via combustion in situ.

Total Petroleum Hydrocarbon (TPH) concentrations were reduced by more than 90% within the target treatment zone (Figure 4) and photographs of 'Before' and 'After' soil cores confirm the degree of treatment (Figures 5a and 5b).

Conclusions

The STAR technology is a rapid, safe, and low cost remedial alternative for source areas.

The STAR PDE at the Michigan former refinery Site:

- Included a "Standard" combustion test and an "EVO enhanced" combustion test;
- Successfully demonstrated the use of a surrogate fuel (EVO) to support the combustion of high volatility (GRO) compounds;
- Showed a ROI of approximately 10 ft with a combustion front propagation rate of approximately 1.3 ft per day (during the EVO enhanced test); and
- Resulted in TPH concentration reductions of two to three orders of magnitude in the treatment zone.

Figure 1: PDE test area showing the ignition/air injection well, associated thermocouple network, and the STAR control trailer.

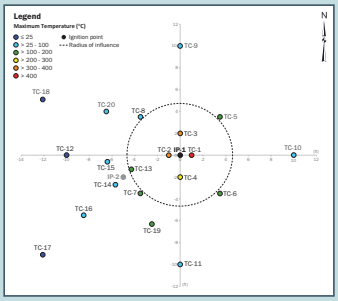

Figure 2: Recorded subsurface temperatures and extent of treatment during the "Standard" STAR test.

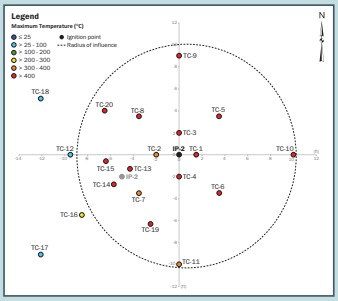

Figure 3: Recorded subsurface temperatures and extent of treatment during the "EVO enhanced" STAR test.

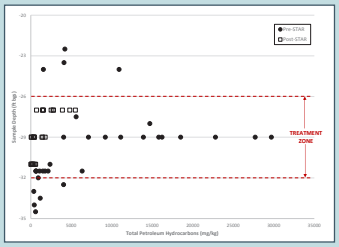

Figure 4: Pre- and post-STAR Total Petroleum Hydrocarbon concentrations for the "EVO enhanced" test.

BEFORE

Figure 5a: Pre-PDE soil core collected within the target treatment zone

AFTER

Figure 5b: Post-PDE soil core collected within the target treatment zone