STAR (In Situ) Pilot Test for the Treatment of Petroleum Hydrocarbon-Impacted Soils

Former Waste Oil Refinery, Chia-Yi, Taiwan

IMAGE 1: PDE test area and equipment setup on Site

Overview

The subject site is a former waste oil refinery located in a mixed use industrial, commercial, and residential area of Chia-Yi, Taiwan. Petroleum hydrocarbon impacts are present in a fine silty sand layer from approximately 5 to 5.8 meters below ground surface (m bgs). This target treatment zone is overlain by a silty clay layer extending to near ground surface. A STAR Pre-Design Evaluation (PDE) was conducted in partnership with Innofusion Environmental Management (IFEM) to evaluate treatment efficiency, radius of influence (ROI), combustion front propagation rate, and volatile mass loading (IMAGE 1). A sustainability analysis was also conducted by IFEM to compare STAR sustainability metrics to other remediation alternatives under evaluation.

Conclusions

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

The STAR PDE in Chia-Yi:

- Resulted in order of magnitude concentration reductions of petroleum hydrocarbons demonstrating excellent treatment efficiency;
- Demonstrated a more rapid remediation alternative to reduce the duration of disruption to nearby residential areas;
- Provided design data to evaluate sustainability metrics for full-scale STAR operations and demonstrated a reduced environmental footprint in comparison to other remediation alternatives.

Pre-Design Evaluation

Due to site constraints, a 72-hour operational window was available for the STAR PDE. During this period, smoldering combustion was initiated and propagated radially through the impacted zone. Total Petroleum Hydrocarbon (TPH) concentrations in soils within the treatment area were reduced from an average of 11,400 milligrams per kilogram to a few hundred milligrams per kilogram. Photographs of 'Before' and 'After' soil cores confirm the degree of treatment within the target treatment interval (IMAGE 2a and 2b).

IMAGE 2A: Pre-PDE soil core from 5 to 6 m bgs

IMAGE 2B: Post-PDE soil core from 5 to 6 m bgs

A sustainability analysis was conducted by IFEM comparing STAR to in-situ chemical oxidation (ISCO) and excavation / off-site disposal (IMAGE 3). A series of sustainability metrics (e.g., greenhouse gas emissions, fresh water consumption, material use, employment, capital costs, and community impacts) were assigned a quantitative score from 1 to 5, with increasing numeric value representing increasing sustainability. The average score for metrics categorized as environmental, social, and economic considerations were then added to give an overall sustainability score (out of a maximum of 15). STAR, ISCO, and excavation / disposal achieved sustainability scores of 11.6, 11.4 and 6.4, respectively. ISCO provided the greatest economic benefits due to a longer treatment duration and resulting long-term job opportunities; however, STAR was determined to be more sustainable overall, with the greatest benefits for both environmental and social considerations at the site.

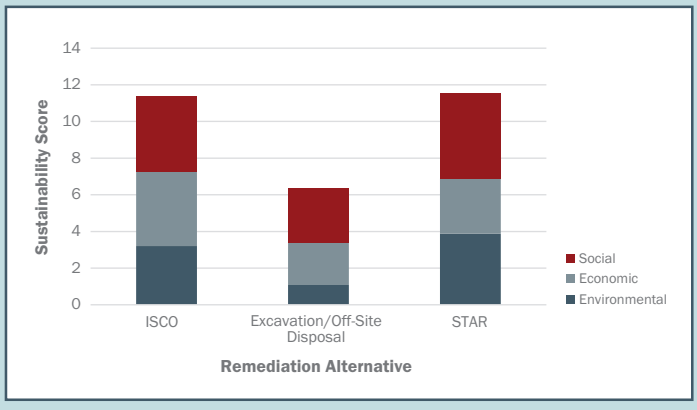

IMAGE 3: Sustainability analysis for remediation alternatives (IFEM, 2018)