REGENESIS®

Combined Remedy Leads to Site Closure

Soil Mixing and ISCO Approach Achieves Arizona DEQ Closure and Saves Client Over $500K

Overview

Antea Group Employs Innovative ISCO Approach to Achieve Regulatory Closure, Saving Client Over $500K

Challenge

Active UST case needed to meet ADEQ closure eligibility quickly as part of property transaction

Solution

Combined soil mixing and ISCO approach rapidly meets levels for ADEQ closure eligibility, while saving $500,000 vs. electrical resistance heating (or thermal treatment) approach

Faster

50-70% Faster Than Thermal Treatment Approach

More Cost-Effective

$500,000 Saved vs. Thermal Approach

Results

Regulatory Closure Achieved

A former industrial manufacturing facility in western Arizona had an active Underground Storage Tank (UST) case with the State of Arizona Department of Environmental Quality (ADEQ) for over 30 years. The facility was used for commercial manufacturing in a downtown urban area. The site's long history of remediation activities included free product skimming, dual-phase extraction, soil vapor extraction (SVE), and a few excavations to remove petroleum hydrocarbon-impacted soils.

Antea Group®, a leading global environmental consulting firm, was transitioned as the primary consultant for the site in late 2016 to perform remedial site characterization activities and determine an effective and timely path to closure to enable a property transaction at the site. These efforts led to Antea Group developing a remediation plan for *in situ* soil mixing using RegenOx® and ORC Advanced® in the most highly contaminated zone and *in situ* chemical oxidation (ISCO) injections using PersulfOx® elsewhere in the plume. The approach was favored over several remedial alternatives, including thermal (i.e., electrical resistance heating or ERH) treatment.

The *in situ* soil mixing and ISCO injections were conducted during two separate mobilizations in the Fall of 2017. The work was safely completed days ahead of the proposed schedule.

Following remedy implementation, Antea Group completed performance monitoring and plume stability analysis modeling. These activities demonstrated that the plume was decreasing and not a threat to impact drinking water, prompting the ADEQ to grant closure to the long-open site case. The highly successful approach is estimated to have saved the project over $500,000 compared to remedial alternatives.

Remedial Evaluation

In Situ soil mixing Using RegenOx and PersulfOx Injections Selected as Most Cost-Effective Option

Design Verification Testing (DVT) Provides Valuable Information to Target the Remediation

To support the remedial design and improve remedial outcomes, Antea Group performed DVT, including advancing 15 Membrane Interface Probe (MIP) borings and collecting six soil/groundwater samples. Soil samples were submitted to REGENESIS for Soil Oxidant Demand (SOD) testing to determine the loadings of oxidants needed for the project. The MIP results were also used to create a 3D model that mapped onsite hydrocarbon impacts' remaining horizontal and vertical extent.

The responsible party was motivated to remediate the site and obtain regulatory closure in order to sell the property. As part of this process, Antea Group evaluated several remedial options to address the remaining PHCs and collected additional data to support a remedial design. The primary PHC contaminants of concern were benzene and ethylbenzene. The remedial options evaluated, included: monitored natural attenuation, air sparging and soil vapor extraction (AS/SVE), and *in situ* chemical oxidation (ISCO) injections combined with ISCO soil mixing, excavation, or ERH.

In completing the evaluation, the project team specified addressing the remaining PHC impacts with a combined remedy of ISCO soil mixing with RegenOx® and ORC Advanced®; PersulfOx® ISCO injections; and monitored natural attenuation (or MNA). The remedial design directed these remedial approaches to three areas of the plume based on the measured total petroleum hydrocarbon (TPH) soil concentrations, as summarized below:

Source Zone (>10,000 mg/kg TPH)	Soil mixing with RegenOx ISCO (catalyzed with hydrogen peroxide) and ORC Advanced.	REGEN Ox ORC OXYGEN RELEASE COMPOUND
Plume core (<10,000 mg/kg TPH)	PersulfOx Injections	PERSULF Ox
Dissolved Plume Extent (low soil impacts)	MNA to determine dissolved phase plume is stable and decreasing.	

This combined approach was chosen based on technical feasibility, time, and cost, which resulted in saving Antea Group's client approximately $500,000 vs. ERH. Moreover, treatment would be completed in less than 3 months vs. 6 to 9 months compared to an ERH approach.

Application

Source Area Soil Mixing RegenOx and ORC Advanced Design Summary

Area Treated	11,000 square feet
RegenOx Part A	71,300 pounds
RegenOx Part B	2,550 gallons
ORC Advanced	600 pounds

Core Plume PersulfOx Injection Summary:

Area Treated	11,000 square feet
PersulfOx Applied	71,300 pounds (mixed and applied as a 15% solution)
Injection Points	150
Effective spacing	8.5 feet (approx.)

Challenged with an Aggressive Timeline, RRS Finishes Ahead of Schedule

The ISCO soil mixing application in the Source Area was completed over one week in October 2017 by a contracted source. Following removal of the "clean" overburden, a rotary mixing tool attached to an excavator was used to directly mix RegenOx and ORC Advanced amendments into the treatment zone. Approximately 1,400 gallons of hydrogen peroxide solution were added to the makeup water as part of the soil mixing amendment formula.

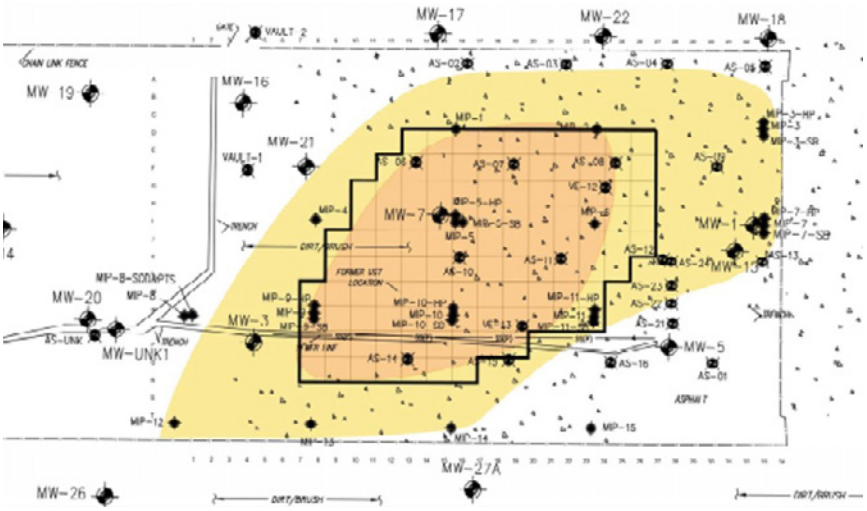


Figure depicting soil mixing area (black polygon) and injection area (gold shaded area outside of black polygon)

REGENESIS® Remediation Services

In December 2017, REGENESIS Remediation Services (RRS) completed the PersulfOx injections in the core plume area, using direct push injection methods and a low-pressure delivery system to apply the PersulfOx solution into the target zone.

Significant design changes were made throughout the project to accommodate recent changes in groundwater depth, baseline TPH data showing higher concentrations in the source zone than previously measured, and soil compaction/stabilization requirements.

Additionally, RRS was challenged to meet an aggressive timeline for the ISCO injections and was able to do so, completing the project 3.5 days ahead of schedule.

"The field crew made execution of the design simple. The RRS team communicated well with the drilling contractor and through their hard work and efficient execution, allowed the project, which was bid on an aggressive schedule, to be completed 3.5 days early."

– Antea Group

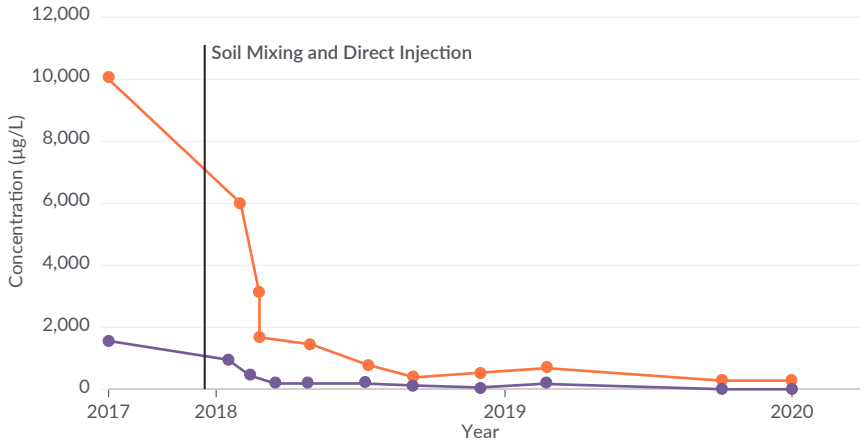
Results

Case Closed: ADEQ Issues Closure of a 30-Year Open Incident

PHC contaminants were sharply reduced following the implementation of the combined ISCO remedy. Concentrations of the primary contaminants of concern—benzene and ethylbenzene—were reduced by approximately 85% in the source area and 70% in the plume core.

MW-7/7A Benzene and Ethylbenzene Concentrations

Benzene and ethylbenzene in MW-7/7A, located in the Source Zone- ISCO Soil Mixing Area before and after combined remedy in late 2017.

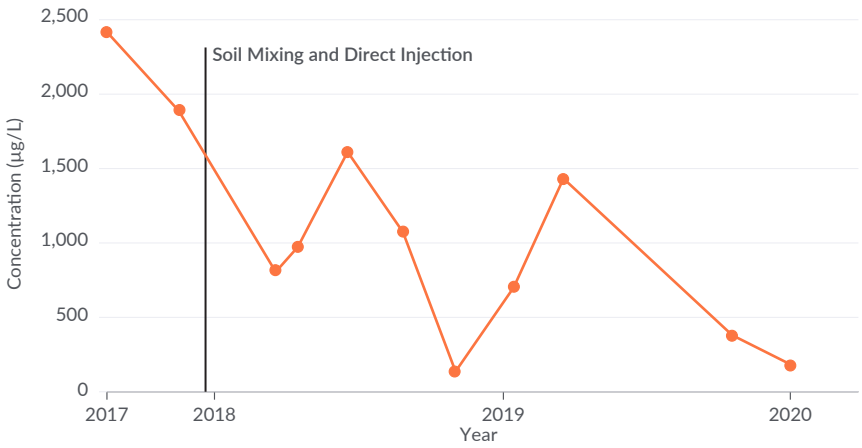


"The results of the corrective action completed at the site assure protection of public health, welfare and the environment, to the extent practicable, the clean-up activities competed at this site allow for the maximum beneficial use of the site, while being reasonable, necessary and cost effective."

-ADEQ Technical Support Document
Proposed UST Release Case, Closure Evaluation Summary
October, 5, 2020.

MW-3 Benzene and Ethylbenzene Concentrations

Benzene and ethylbenzene in MW-3, located in the Plume Core – ISCO Injection Area, before and after combined remedy in late 2017.



With the remedy of the high-concentration plume areas in place, a natural attenuation assessment was conducted to evaluate overall groundwater plume stability. Antea Group used U.S. EPA's BIOSCREEN model to predict the plume's limited potential extent and conducted a Mann-Kendall analysis showing decreasing trends across the groundwater monitoring well network, informed by 30 years of monitoring data. Further, a well survey identified no drinking water wells within one-half mile of the site.

Based on the results of the combined ISCO soil mixing, ISCO injection, and MNA remedy, ADEQ granted closure of the release case in October 2020, concluding that the corrective action *"assure[s] protection of public health, welfare, and the environment, to the extent practicable… while being reasonable, necessary and cost effective."*

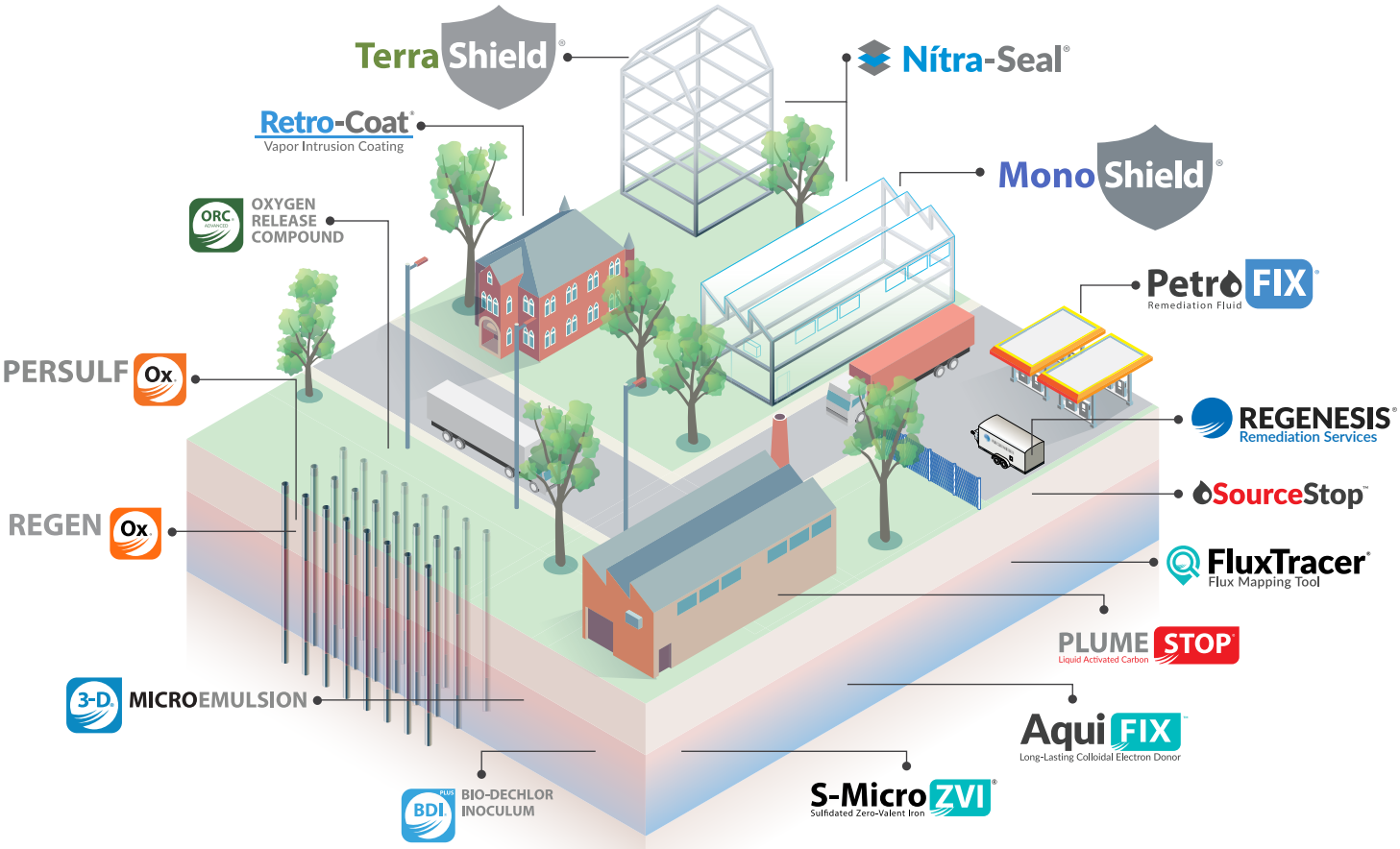
"The REGENESIS team was instrumental in assisting with our design and execution of the remediation strategy at our site. REGENESIS worked hand in hand with our engineering team to determine an appropriate remediation strategy to meet our cleanup goals. REGENESIS' ability to always pick up the phone, despite their busy schedule and give prompt and clear responses to design questions is extremely valuable."

- Antea Group

About the Consultant

anteagroup

Antea Group is an international engineering and environmental consulting firm specializing in full-service solutions in the fields of environment, infrastructure, urban planning and water. By combining strategic thinking, multidisciplinary perspectives and technical expertise, Antea Group does more than effectively solve client challenges–they deliver sustainable results for a better future. With more than 3,100 employees in over 80 offices around the world, Antea Group serves clients ranging from global energy companies and manufacturers to national governments and local municipalities.



About REGENESIS

At REGENESIS we value innovation, technology, expertise and people which together form the unique framework we operate in as an organization. We see innovation and technology as inseparably linked with one being born out of the other.

Inherently, innovation imparts new and better ways of thinking and doing. For us this means delivering expert environmental solutions in the form of the most advanced and effective technologies and services available today.

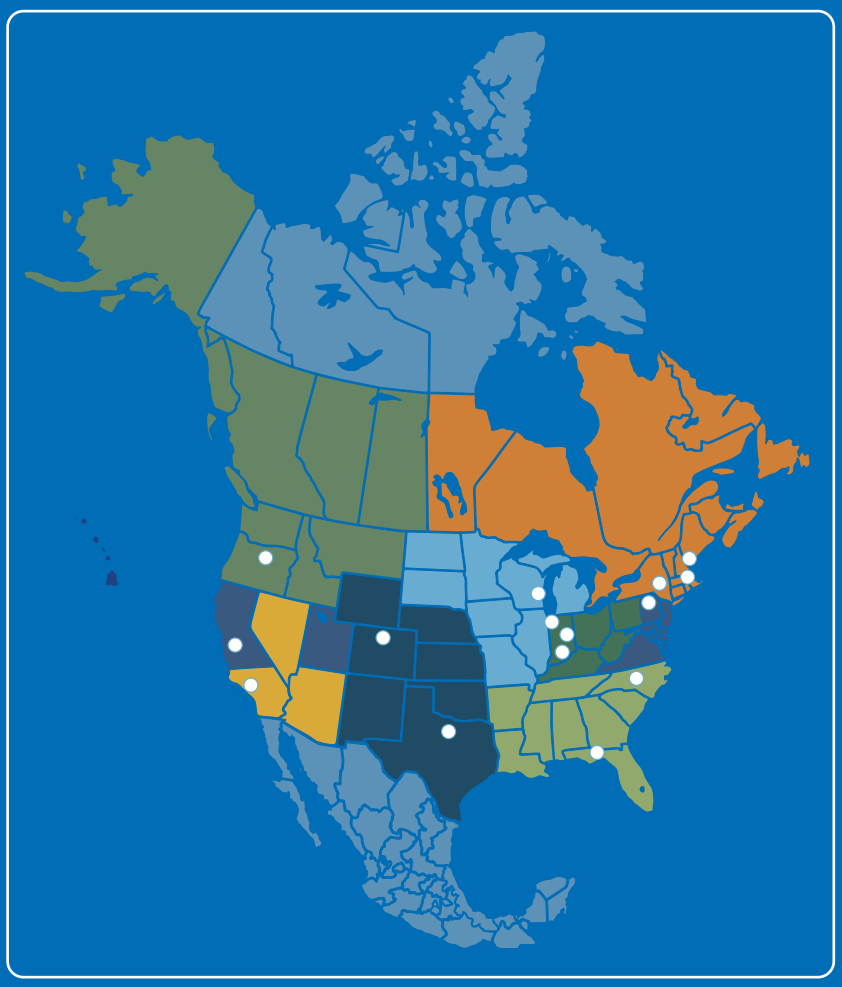
We value expertise, both our customers' and our own. We find that when our experienced staff collaborates directly with customers on complex problems there is a high potential for success including savings in time, resources and cost.

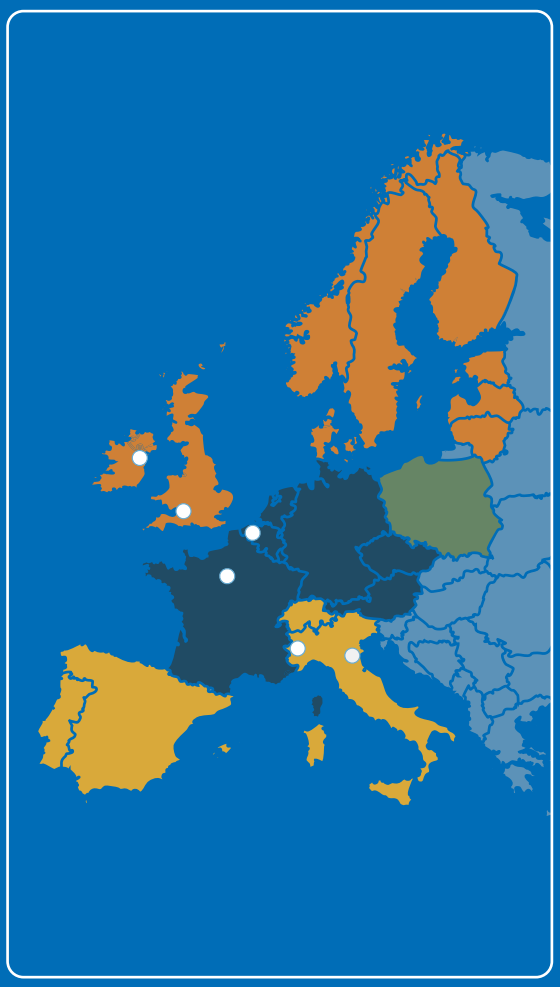
At REGENESIS we are driven by a strong sense of responsibility to the people charged with managing the complex environmental problems we encounter and to the people involved in developing and implementing our technology-based solutions. We are committed to investing in lasting relationships by taking time to understand the people we work with and their circumstances. We believe this is a key factor in achieving successful project outcomes.

We believe that by acting under this set of values, we can work with our customers to achieve a cleaner, healthier, and more prosperous world.

REGENESIS®

We're Ready to Help You Find the Right Solution For Your Site





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