REGENESIS®

Effective 3-D Microemulsion Treatment of a CrVI Plume, Enables Site Redevelopment in Spain

Highlights

Site Type
Former chromium plating facility

Project Drivers
Redevelopment of contaminated site for retail use, downgradient receptor: a nearby river

Contaminants
CrVI in groundwater, with concentrations exceeding 10,000 µg/L and residual soil concentrations up to 2,100 mg/kg

Geology
Fill material, sandy silt and gravel in silty matrix, lutite/ marl bedrock

Treatment
In situ immobilization and reduction of CrVI

Technologies
3-D Microemulsion

Quantity Injected
Approximately 3,800 kg

Other Site Considerations
Previous excavation works had not reduced groundwater concentrations to acceptable levels.

Summary

In a town in Spain's Basque Country, a former cutlery manufacturing site contaminated with hexavalent chromium (CrVI, Cr6) was slated for redevelopment into retail use. High CrVI concentrations in the groundwater—originating from historic plating operations—posed a significant risk to a nearby river. A targeted in situ remediation strategy using 3-D Microemulsion® was implemented to address both source and plume areas. Pilot testing demonstrated rapid and far-reaching reductions in CrVI levels, enabling a streamlined full-scale design. The project achieved the site-specific remediation targets cost-effectively, including offsite improvements, without requiring repeat injections or extensive infrastructure. The property has since been sold and is now under active redevelopment.

Background and Treatment Goals

Once home to a thriving cutlery manufacturer, this site became contaminated due to historic chromium plating operations, with a prominent CrVI source zone identified beneath the former plating area. Despite soil excavation to bedrock in the source zone, elevated CrVI concentrations exceeding 10,000 µg/L persisted in the groundwater, migrating along a narrow paleochannel toward a nearby river. The highly aerobic groundwater conditions sustained these elevated CrVI levels, resulting in detection in monitoring wells adjacent to the river.

Regulatory requirements and plans for redevelopment by the current site owners called for a low-disruption, effective remediation approach that could be implemented beneath the existing building. Given the complexities of performing proactive remediation off-site—such as permitting challenges and utility verification—the project team sought a remedial solution to be undertaken within the property footprint, that would not only address on-site contamination, but also effectively reduce CrVI concentrations to below the off-site cleanup goal of 100 µg/L.

3-D Microemulsion, which leverages advection to effectively distribute through groundwater post-injection, was selected to reduce CrVI concentrations both on- and off-site. The technology was particularly attractive given the project's need to minimize costs following high preliminary expenses and a slow return on investment. Dinam Ingeniería, with technical support from REGENESIS, implemented a phased treatment strategy, starting with a field-scale pilot study.

Application

Pilot Test

During the pilot study, 3-D Microemulsion was injected in a staggered injection barrier. After one month, samples were collected showing effectiveness in wells up to 20 meters downgradient. Geochemical indicators reinforced the success: total organic carbon (TOC) and manganese increased at distance from injection points, signaling strong subsurface distribution of 3-D Microemulsion. Nitrate concentrations decreased as expected, while sulfate levels remained stable—suggesting that the treatment had not shifted conditions excessively and was well-calibrated to reduce CrVI without triggering unnecessary sulfate reduction. One year of pilot test monitoring confirmed continued progress and plume shrinkage, evidencing also the controlled and long-term release profile of the technology. These strong pilot results allowed for a reduced full-scale design, lowering the number of injection points needed and saving overall project cost to meet the regulatory goals for both onsite and offsite areas.

Full-Scale Implementation

Based on the success of the pilot test, a full-scale injection plan was implemented one year later. The pilot data enabled a more refined design, significantly reducing the number of required injection points compared to initial concepts. The full-scale strategy targeted both the source zone and the downgradient plume. A regular injection grid was used in the source area to ensure comprehensive coverage, while multiple treatment barriers were established across the plume to intercept contaminant migration. Injection intervals were tailored in real time, based on the depth to bedrock encountered during drilling—ranging from 3.0 to 3.7 meters—to ensure optimal placement of the amendment in the treatment zone.

Application Details

Source Zone Treatment

Grid Spacing	3 x 3 m
Injection Points	16
Dose	72 kg/point
Injection Volume	12,800 L

Plume Treatment

Barriers	4 staggered lines
Injection Points	29 (total)
Dose	91 kg/point
Injection Volume	29,000 L

Total 3-D Microemulsion Injected for Full-Scale Application

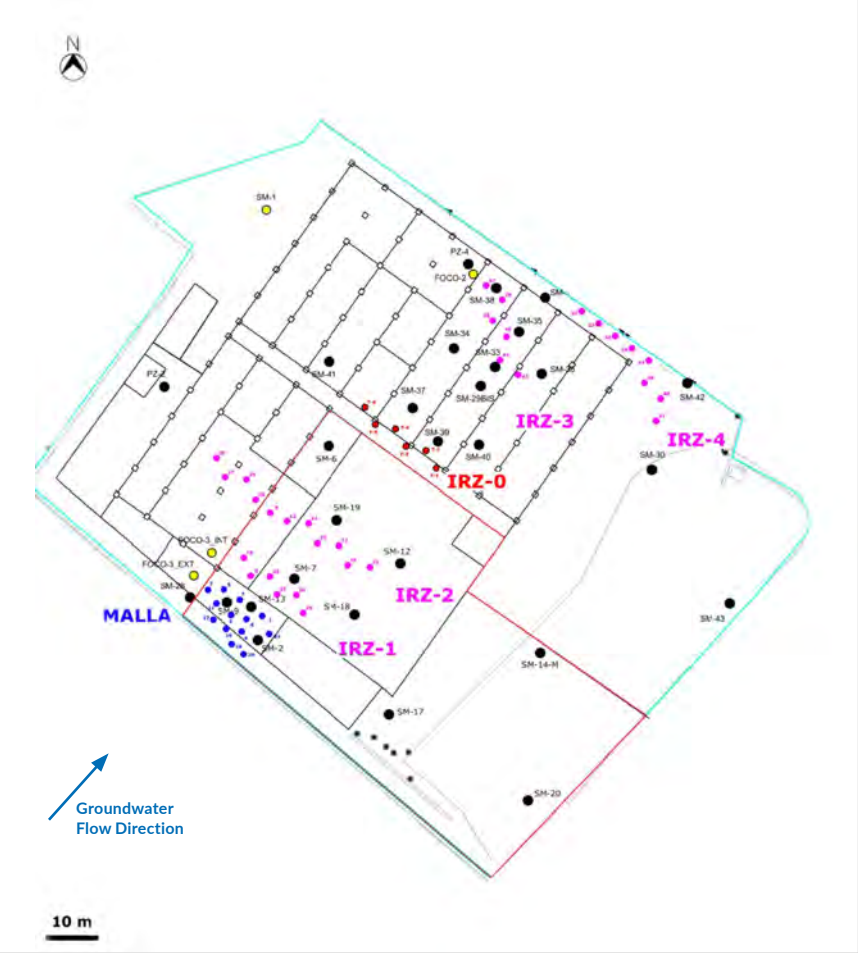
Quantity	Approx. 3,800 kg

Figure 1

Site Map

Injection map, depicting injection points (coloured dots) and piezometers used for monitoring (black dots)

- Pilot Test
- Full-Scale Source Treatment
- Full-Scale Barriers



The 3-D Microemulsion injection was performed using direct-push equipment using a retractable tip with 30 cm step intervals, at low pressure (2–3 bars), to promote uniform distribution through the 2-meter vertical saturated zone. Part of the work was conducted inside the old industrial building.

Results

The results of the remediation were both immediate and sustained, resulting in CrVI concentrations being reduced below the Off-site Cleanup Goal (i.e., the most stringent) of 100 µg/L at all monitoring locations. In monitoring points located directly downgradient of the treatment areas, CrVI concentrations dropped several orders of magnitude, from over 10,000 µg/L to non-detect levels in less than one month. Monitoring wells located more than 20 meters away showed significant reductions, indicating effective, advective-driven treatment distribution and rapid contaminant immobilization. Off-site improvements were also observed, despite all injections being performed solely on the property.

Figure 2

Property North

Chart showing remediation performance following 3-D Microemulsion application in the northern portion of the site.

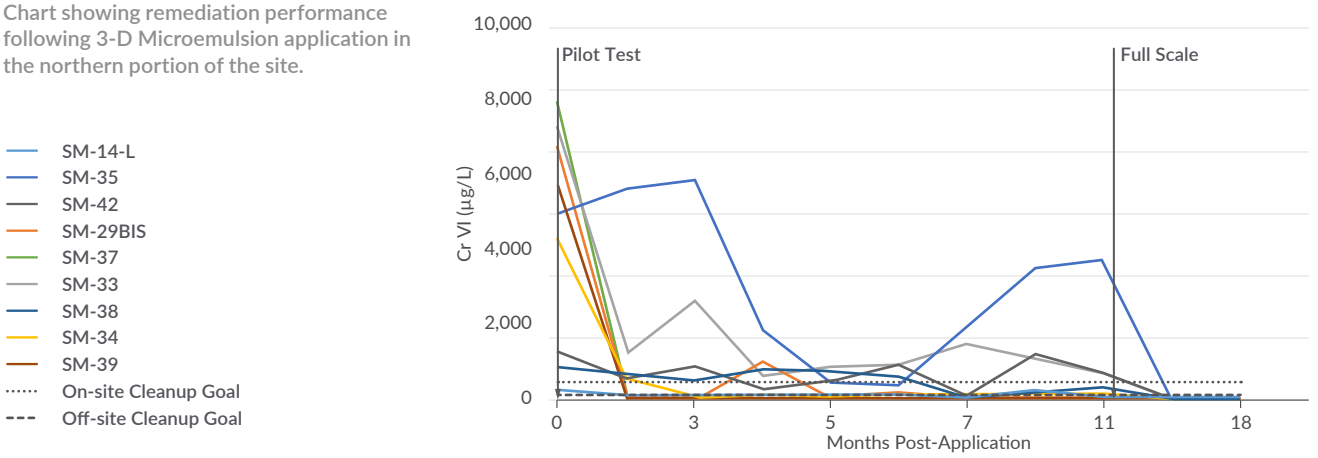


Figure 3

Property South

Chart showing remediation performance following 3-D Microemulsion application in the southern portion of the site.

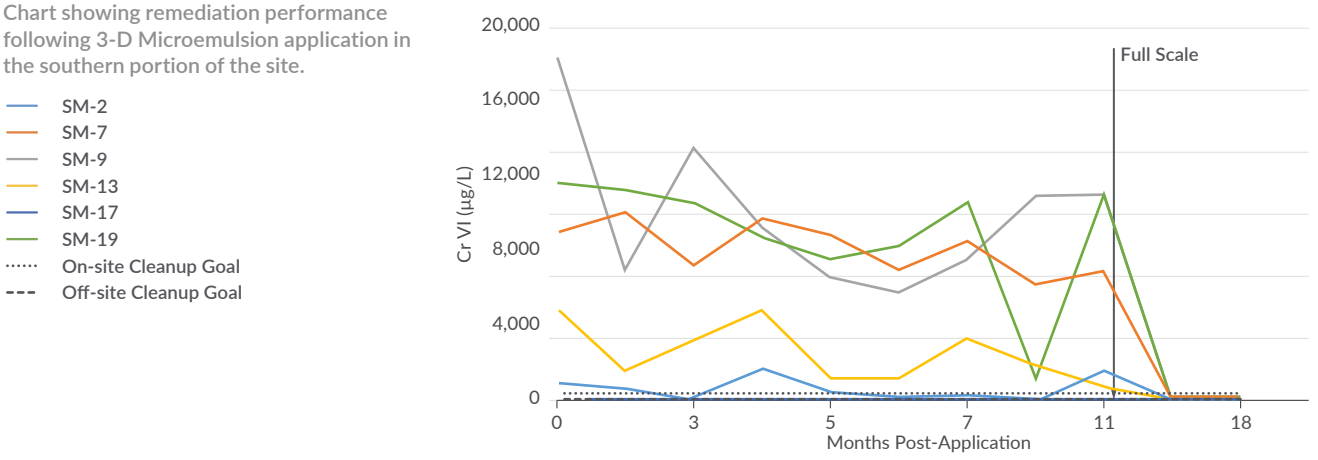


Figure 4 Off-site

Chart showing off-site remediation performance following 3-D Microemulsion application.

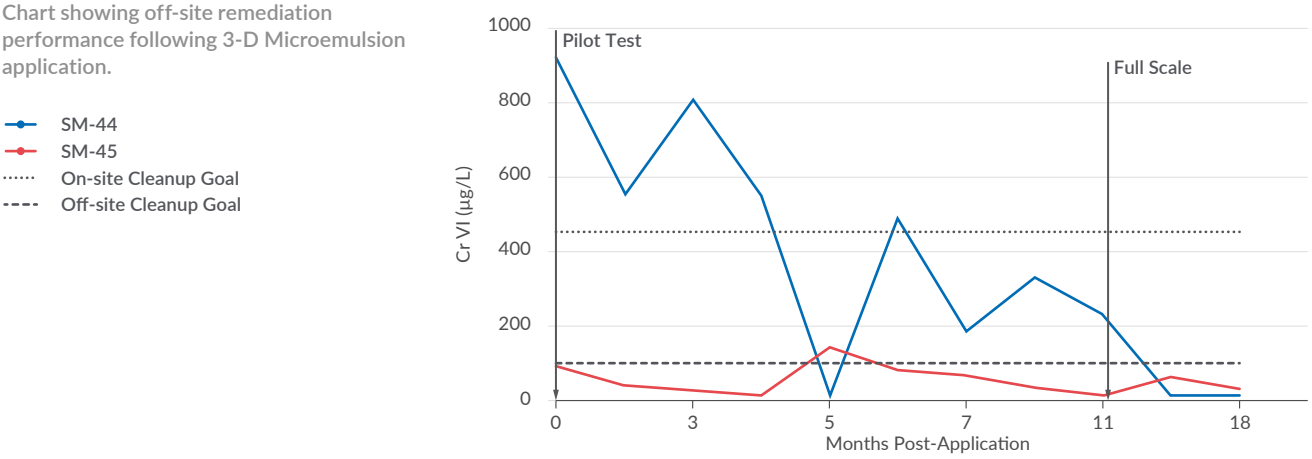
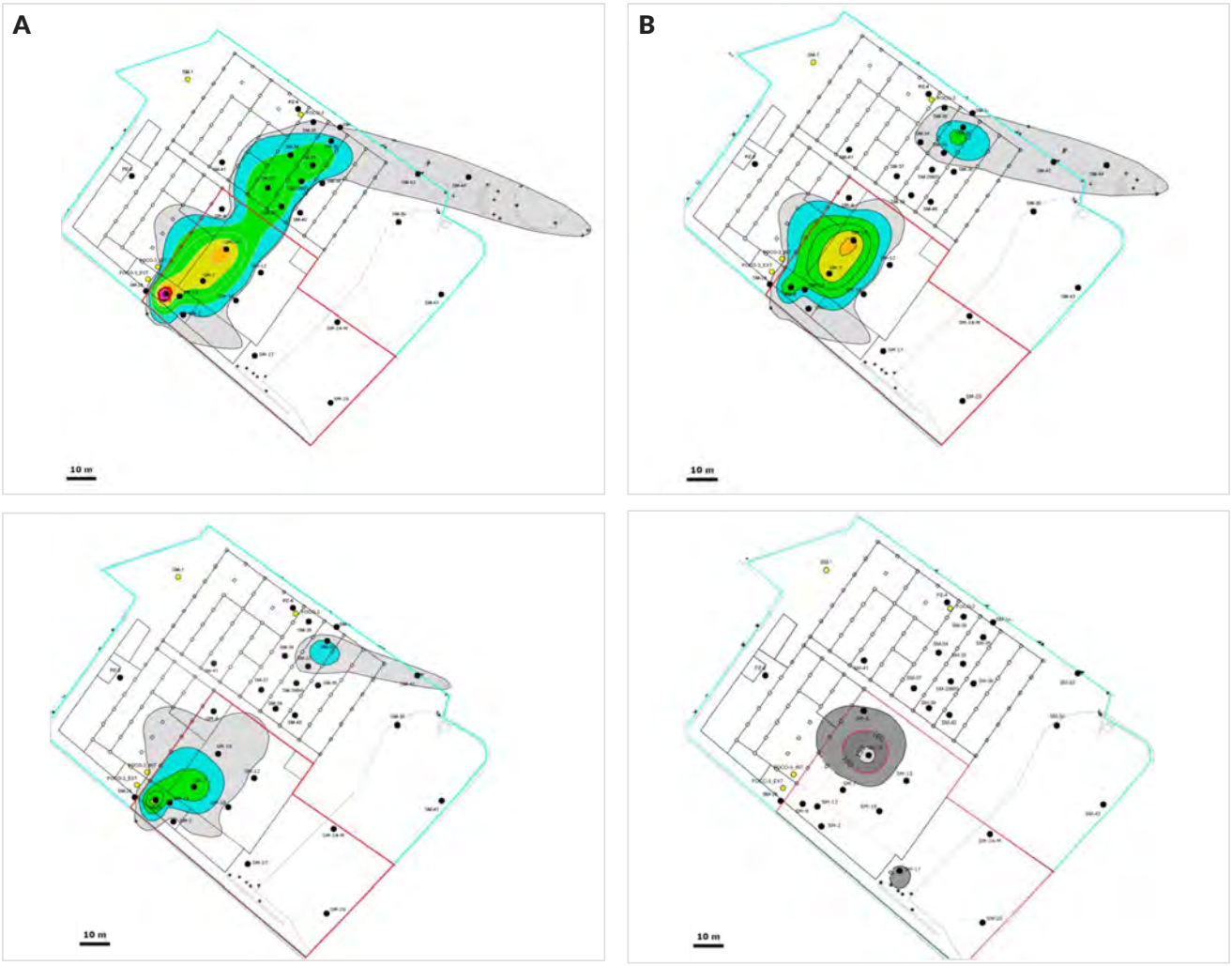


Figure 5 Isopleth Maps



Isopleth maps depicting CrVI concentrations at: A. 0 months (baseline); B. 1 month (pilot study phase); C: 9 months post-pilot application; and, D. 18 months post-pilot application and 7 months after Full-Scale.

Conclusion

The remediation of CrVI using 3-D Microemulsion allowed for effective source treatment and plume control, even under complex hydrogeologic and site-access conditions. This high-performance technology not only met cleanup objectives onsite but significantly reduced risk offsite to acceptable levels as well. By leveraging the results from the pilot, the full-scale design was optimized to minimize cost and maximize performance. With no need for repeat injections or additional infrastructure, redevelopment could proceed without delay.

Another benefit of using 3-D Microemulsion at the site was its ability to address low-level background concentrations (<10 µg/L) of chlorinated solvents such as trichloroethene (TCE), dichloroethene (DCE), vinyl chloride (VC), and chloroform. Although not formally part of the remediation plan, this additional contaminant reduction underscores the longevity and comprehensive effectiveness of the 3-D Microemulsion treatment at the site.

About the Consultant

Dinam is a Spanish company established in 2006, with 3 local offices in the Basque Country provinces of Bizkaia, Alava and Gipuzkoa. Dinam develops and offers a comprehensive environmental management service to companies, focused on the promotion, management and development of environmental infrastructures, to propose innovative solutions to current problems of waste management and contaminated land. The services include environmental consultancy and technical assistance and the development and implementation of innovative environmental infrastructures.

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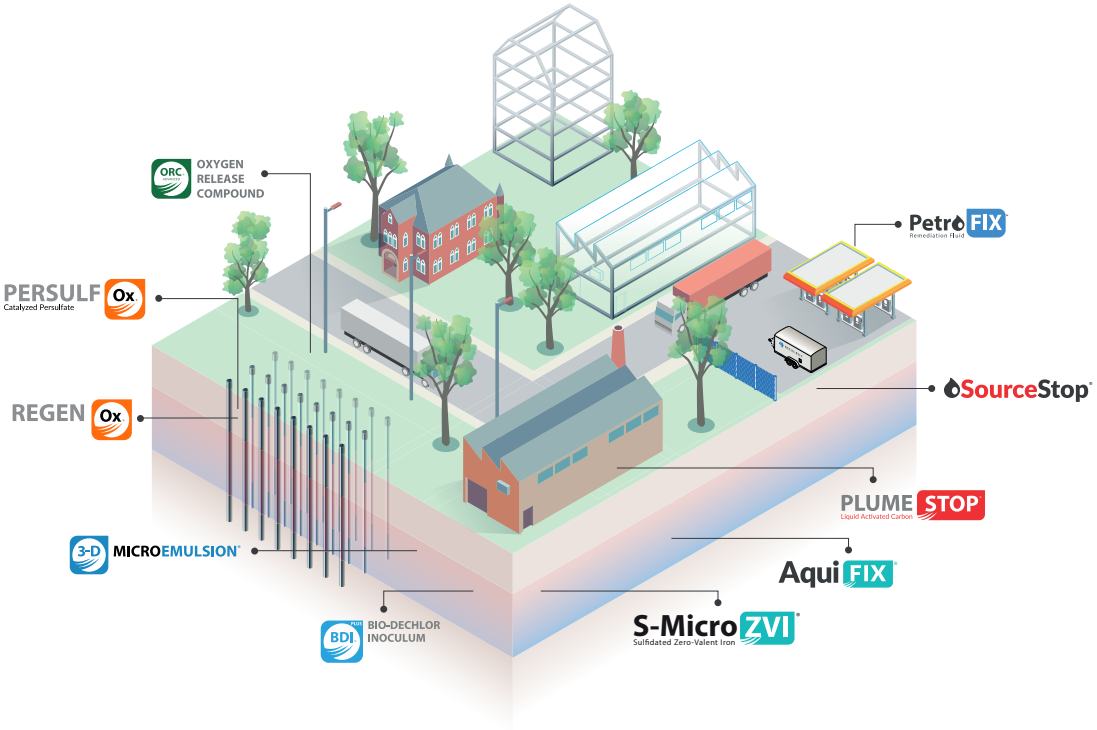


PlumeStop® Liquid Activated Carbon™ is composed of very fine (1-2 micron-size) activated particles suspended in water through a unique, organic polymeric dispersion chemistry that resists clumping and allows permeation through aquifer materials. PlumeStop sorbs to the aquifer matrix soon after injection, rapidly removing contaminants from the groundwater to eliminate risk. It can be co-applied with electron donors, electron acceptors, or used as a stand-alone amendment to treat most organic groundwater contaminants.

SourceStop® prevents leaching of PFAS from soils and halts further migration in groundwater to eliminate the risk to downgradient receptors. Available in Liquid and Solid formulations, SourceStop's colloidal activated carbon (CAC) technology provides unsurpassed distribution, penetrating and permanently coating impacted soils. Engineered for easy application, rapid results and long-term treatment, SourceStop is an adaptable and affordable solution for PFAS sites.

PetroFix® is a colloidal activated carbon technology used to remediate total petroleum hydrocarbons (TPHs) from contaminated environments. Petrofix uses a proprietary formula of activated carbon to adsorb total petroleum hydrocarbons. It then adds electron acceptors to stimulate hydrocarbon biodegradation.

RegenOx® is an *in situ* chemical oxidation (ISCO) reagent used to directly oxidize contaminants. Its unique catalytic component generates a range of highly oxidizing free radicals that rapidly and effectively destroy a range of target contaminants including both petroleum hydrocarbons and chlorinated compounds. RegenOx is an injectable, two-part ISCO reagent combining a solid sodium percarbonate based alkaline oxidant (Part A), with a liquid mixture of sodium silicates, silica gel and ferrous sulfate (Part B), resulting in a powerful contaminant destroying technology.

PersulfOx® is an advanced *in situ* chemical oxidation (ISCO) reagent that destroys organic contaminants found in groundwater and soil through abiotic chemical oxidation reactions. It is an all-in-one product with a built-in catalyst which activates the sodium persulfate component and generates contaminant-destroying free radicals without the costly and potentially hazardous addition of a separate activator.

ORC Advanced® is an engineered, oxygen-release compound developed for enhanced, *in situ* aerobic bioremediation of petroleum hydrocarbon contaminants in groundwater and saturated soils. Containing 17% by weight molecular oxygen, ORC Advanced provides a controlled release of molecular oxygen-an electron acceptor that optimizes microbial utilization in a treatment zone for up to 12 months post-application.

3-D Microemulsion® is an easy-to-apply remedial amendment for the *in situ* treatment of chlorinated solvent-contaminated aquifers. The patented technology, applied as a micellar suspension, provides a controlled, self-distributing hydrogen source to facilitate biologically mediated enhanced reductive dechlorination. 3-D Microemulsion's unique chemistry enables its distribution by naturally flowing groundwater while persisting for years after injection, resulting in much greater treatment coverage and faster degradation rates than other electron donor amendments.

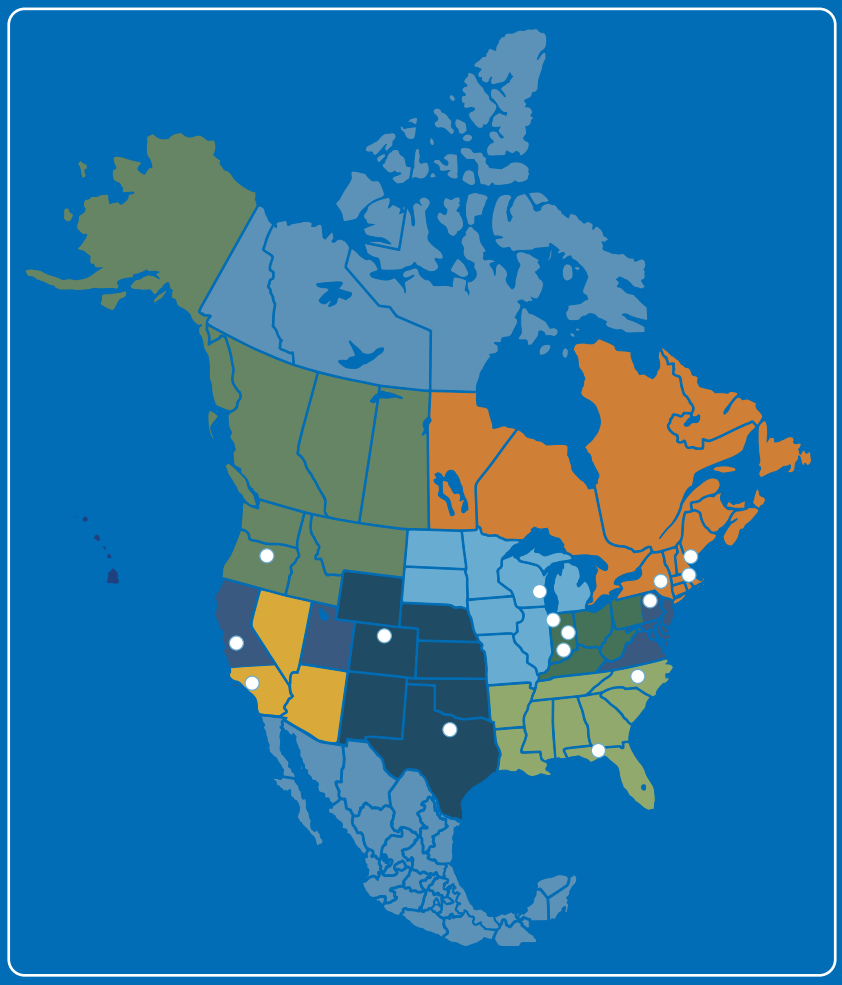
AquiFix™ is a solid, colloidal remediation amendment for the *in situ* treatment of chlorinated solvent-contaminated aquifers, designed for direct mixing and co-application with PlumeStop. The novel formulation, patent-pending, includes a nutrient-enriched, solid-phase, fatty acid source that quickly establishes and sustains enhanced reductive dechlorination over long timeframes (e.g., ten years post-injection). AquiFix's optimized hydrogen release profile significantly improves remediation efficacy and reduces life-cycle costs to treat these contaminants.

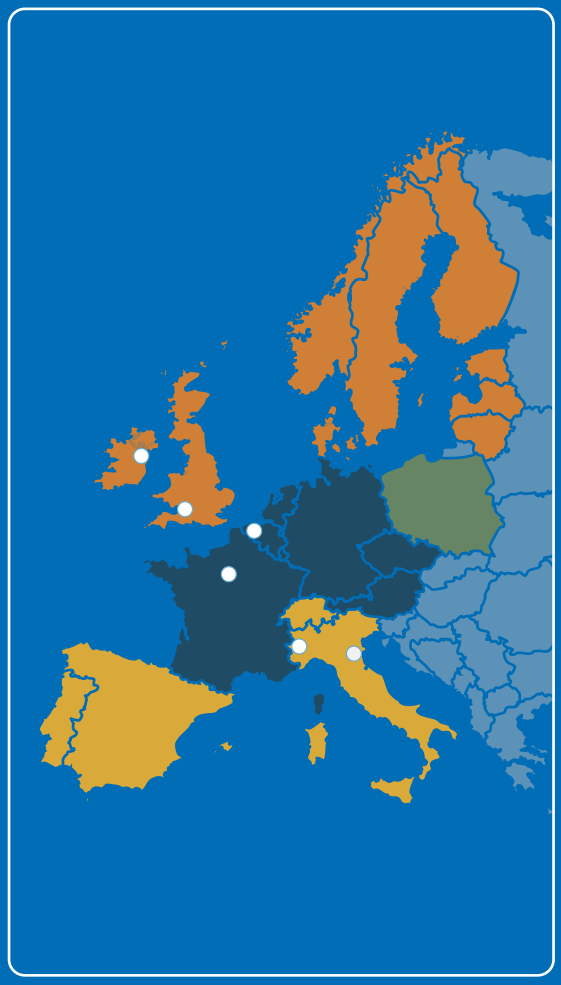
BDI PLUS® (Bio-Dechlor INOCULUM Plus) is an enriched natural consortium containing *Dehalococcoides sp.* and other dechlorinating microbes for biologically augmenting enhanced reductive dechlorination remedies. Co-applied with electron donor amendments such as 3-D Microemulsion and AquiFix, BDI PLUS has proven to improve chlorinated solvent remediation efficiency.

S-MicroZVI® is a colloidal suspension of sulfidated zero-valent iron that promotes the destruction of a wide range of organic pollutants including chlorinated solvents, pesticides, haloalkanes and energetics. S-MicroZVI is engineered to promote rapid contamination degradation through multiple pathways which leads to faster cleanup while minimizing daughter product formation. Compared to larger particle size ZVI products, S-MicroZVI's 2-3 micron-sized particles, suspended in a proprietary polymer, make it easy to handle and simple to inject, leading to significantly better reagent distribution.

REGENESIS®

We're ready to help you find the right solution for your site





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