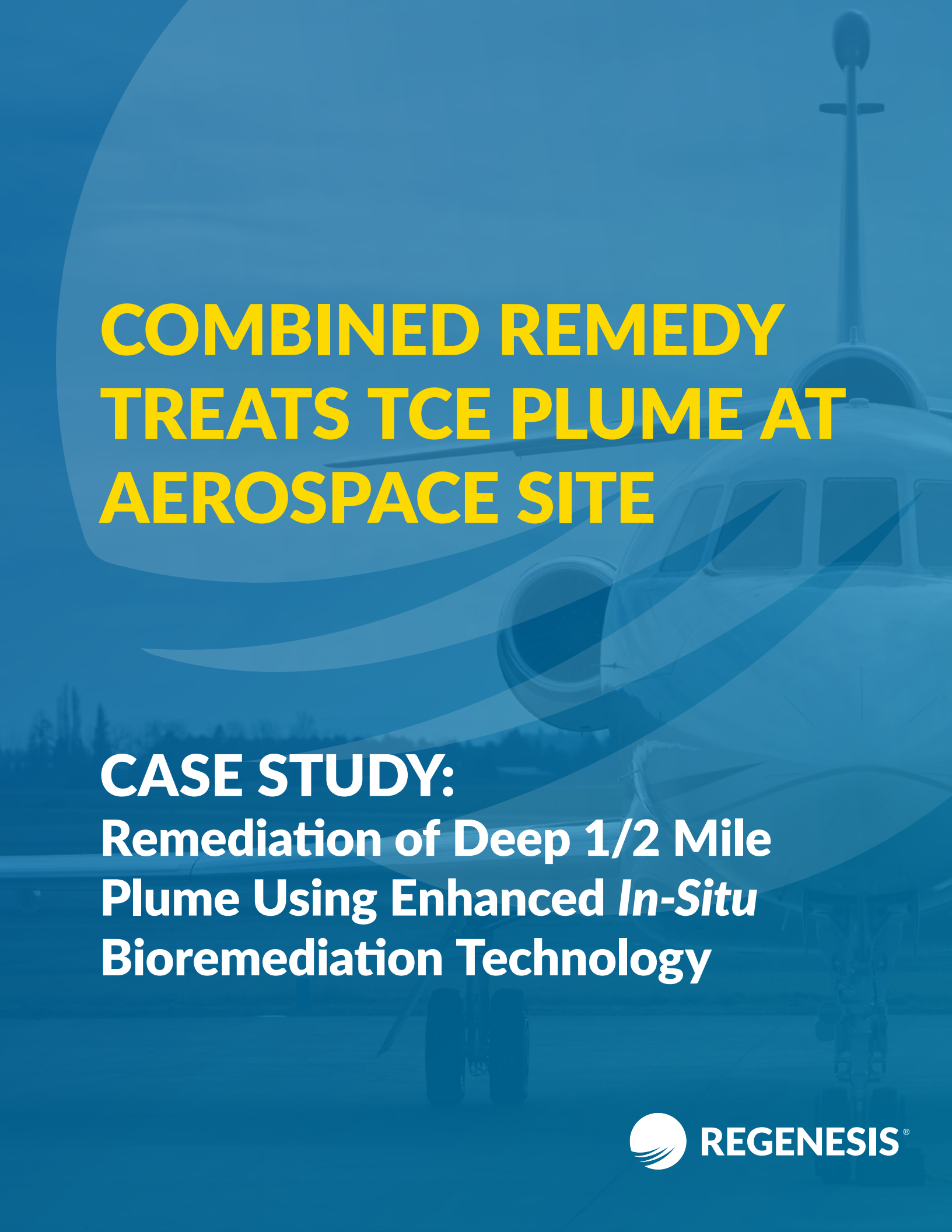
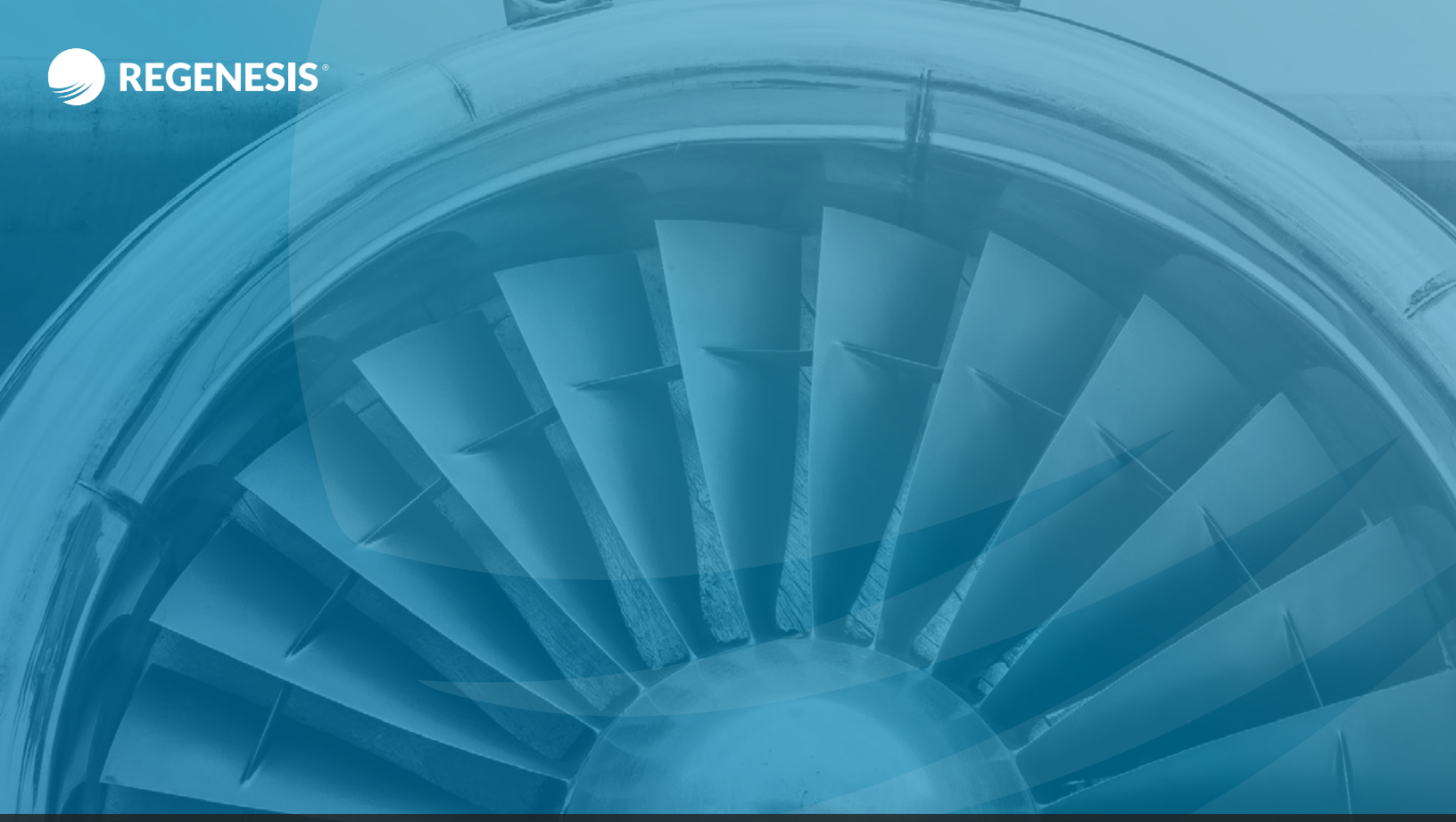


COMBINED REMEDY TREATS TCE PLUME AT AEROSPACE SITE

CASE STUDY:
Remediation of Deep 1/2 Mile Plume Using Enhanced *In-Situ* Bioremediation Technology

REGENESIS®

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SITE CHALLENGE:

Active aerospace site with an impacted deep aquifer required deep multi-nested injection wells for *in situ* remediation. The injection program required an injection radius of 25 feet between the wells located in the Gage aquifer. This required injection rates up to 176 gallons per minute (gpm) to create enough back pressure to overcome semi-plug flow distribution.

More Cost-Effective

3x The Cost Savings
vs. Alternative Remedial Technologies

SOLUTION:

In order to effectively apply the combined remedial amendments, sufficient pressure and volume were applied, overcoming the challenging aquifer. A total of 700,000 gallons of Chemical Reducing Solution® (CRS), 3D-Microemulsion® (3DMe), and Bio-dechlor Innoculum Plus® (BDI+) were applied into 75 dual-nested wells over a six-week period. The total project cost of <$20/CY provided significant savings in comparison with an *In Situ* Chemical Oxidation or Electrical Resistance Heating approach coming in at $50-$150/CY.

Completed Ahead of Schedule

Application Event Ahead of Schedule

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OVERVIEW

An aerospace manufacturing facility in Southern California required remediation for a deep and heavily impacted Chlorinated Volatile Organic Compound (cVOC) plume. The primary contaminant of concern was trichloroethene (TCE). Other cVOCs included tetrachloroethene (PCE), but at lower concentrations. In addition, the extensive depth and size of the plume also contributed to the difficulty facing remediation efforts, with much of the contaminant plume extending offsite. Alta Environmental, the consulting firm hired to provide a remedial solution, and REGENESIS began developing an approach to remediate the site in 2012. After conducting pilot tests, they concluded that Enhanced *In-Situ* Bioremediation (EISB) technology was both cost-effective and feasible for successful remediation of this site. The observation wells continue to be sampled quarterly and are displaying successful reductions in cVOCs.



HIGHLIGHTS

- Alta Environmental and REGENESIS were able to create a remediation plan using Enhanced *In-Situ* Bioremediation (EISB) which was the most cost-effective and feasible solution for this project.
- Safe and successful installation of dual-nested injection wells in the Gage Aquifer (a deep, highly permeable aquifer consisting of “heaving sands”).
- The remediation team created and implemented a plan to shift the aquifer from aerobic to anaerobic.
- Effectively applied remedial technology at very high delivery rates which maximized both lateral and vertical distribution.
- Field work performed at active aerospace manufacturing facility with no disruption to operations or personnel
- Pilot tests performed aided in perfecting design to meet site remediation goals
- Employed a strategic combination of technologies including 3DME, CRS, and BDI Plus.
- REGENESIS met stringent regulatory requirements set by the Los Angeles Regional Water Quality Control Board (LARWQCB) throughout the remediation process.



BACKGROUND

The contaminant plume was located in the Gage Aquifer. This aquifer, located deep below ground surface, consists of a fine-to-medium grained sand with gravel and sandy silt. The large TCE plume was ½ mile long by ¼ mile wide and was located approximately 90 feet below surface level. The size of this plume posed a challenge for the remediation team: typically, a treatment area requires 4,000 gallons of remedial solution per day. However, due to the magnitude of the plume, this site required a minimum of 15,000 gallons of remedial solution per day. In order to achieve this, new equipment had to be designed and multiple pilot tests were undertaken to ensure the success of the remediation.

PROJECT TIMELINE

2012

Design Process Begins

Alta Environmental and REGENESIS began the design process of Enhanced *In-Situ* Bioremediation (EISB) of the cVOC contaminant plume.

2013

First EISB Pilot Test

HRC HYDROGEN RELEASE COMPOUND

3-D MICROEMULSION

2015

Second EISB Pilot Test

CRS CHEMICAL REDUCING SOLUTION

BDI BIO-DECHLOR INOCULUM

3-D MICROEMULSION

2015

Groundwater Monitoring

Following the pilot tests, ongoing groundwater monitoring has taken place.



2016-'17

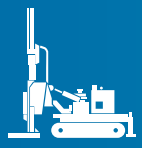
Well Installation

75 dual-nested injection wells were installed in the core of the TCE contaminant plume.

2017

Reagent Applied

Approximately 700,000 gallons of the reagent solution were applied to the injection wells.



CRS CHEMICAL REDUCING SOLUTION

BDI BIO-DECHLOR INOCULUM

3-D MICROEMULSION

2017

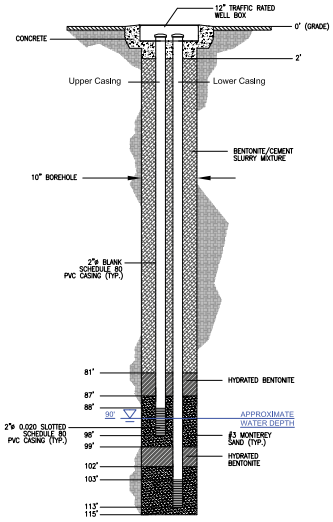
Concentrations Reduced

The most recent monitoring event shows drastic reductions of TCE and PCE in multiple monitoring wells.

APPLICATION

PILOT TEST:

Pilot testing occurred during August 2013 and October 2015. Prior to the first pilot test in August 2013, six injection wells were installed at locations cross-gradient and up-gradient of well M-15, located within the core of the TCE plume. Groundwater monitoring has been conducted continuously at this well since July 2013 (immediately before the August 2013 pilot test). After the remedial solution (3DMe, CRS, and and BDI+) was injected during October 2015, marginal reductions of TCE, increases of *Dehalococcoides sp.* (DHC), increases of degradation products (cis-1,2-dichloroethene and vinyl chloride), and a decrease in dissolved oxygen (DO)/oxidation-reduction potential (ORP) levels were observed at MW-15. Alta concluded that reductive dechlorination and bio-activity processes were being accelerated as a result of the injection.



POST PILOT TEST:

Following the success of the pilot tests, a Groundwater Remedial Action Plan (GWRAP) was prepared and approved by the LARWQB. Between November 2016 and January 2017, 75 dual-nested injection wells, screened at 88-98 and 103-113 feet below surface level, were installed in the core of the TCE plume. The wells located in accessible areas on a modified and staggered 30 ft by 60 ft grid pattern. Following the installation of the wells, between January 2017 and April 2017, approximately 700,000 gallons of the remedial solution was applied to the 75 dual-nested injection wells and to two of the previously installed pilot test injection wells.

APPLICATION APPROACH

The 3DME was mixed and applied as a 5% solution.

The CRS was applied at an approximately 2% solution.

Two liters of BDI Plus (DHC) were applied in-line (4.5 to 7.1 times concentrated) into each injection well.

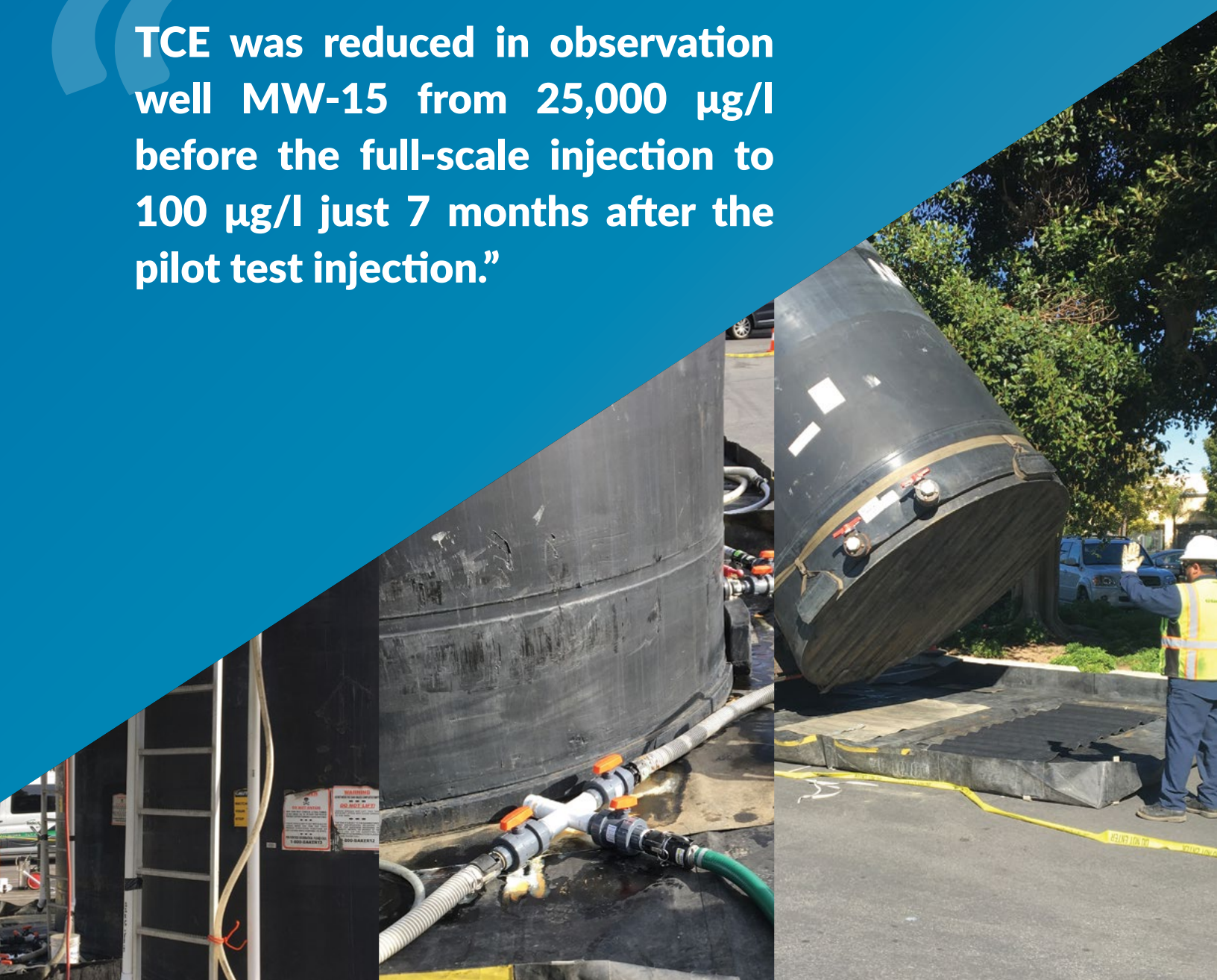
Injection flow rates typically ranged from 40 to 150 gpm

Sustained injection pressures ranged from 0-30 psi.

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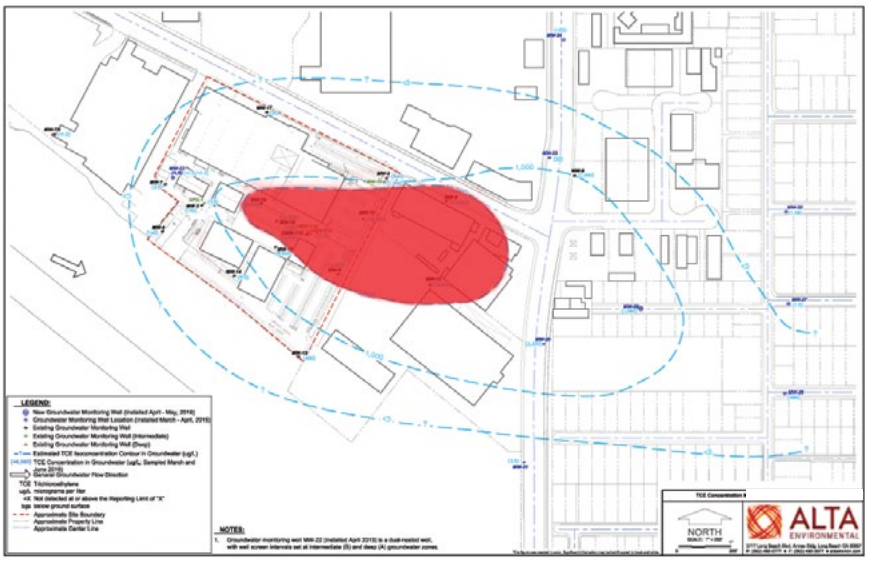
RESULTS:

“TCE was reduced in observation well MW-15 from 25,000 µg/l before the full-scale injection to 100 µg/l just 7 months after the pilot test injection.”

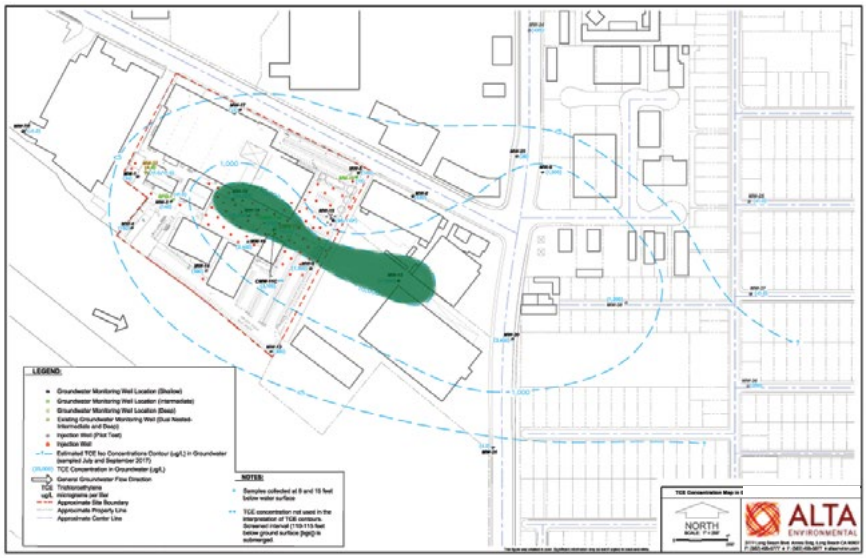


RESULTS

Groundwater monitoring and sampling have been conducted quarterly since the initial pilot tests. Wells MW-6, MW-7R, MW-8, MW-12, MW-15, MW-16, MW-18, MW-19, and CMW-11C were monitored for VOCs, DHC, DO, and ORP, and other parameters required in the LARWQCB's Monitoring and Reporting Program (M&RP). Notably, TCE was reduced in MW-15 from 25,000 µg/l before the full-scale injection to 100 µg/l just 7 months after the injection. During that same time period, PCE was reduced from 570 µg/l to just 10 µg/l. Ethene increased significantly from ND (before the October 2015 pilot test) to as high as 1,260 µg/l (post full-scale injection). DHC concentrations also increased from nearly ND to as high as 1,680,000 cells/ml. Additionally, degradation products cis-1,2-dichloroethene and vinyl chloride were detected. Alta concluded that additional time was needed for the remedial agent to develop and acclimate in other areas of the aquifer. However, results thus far prove the treatment as a success in reducing the size and concentrations of the contaminant plume.



TCE plume map prior to full-scale injection.



TCE plume map five months after full-scale injection.

TECHNOLOGY

3-D MICROEMULSION

3-D Microemulsion® is an injectable liquid material specifically designed for in situ remediation projects where the anaerobic biodegradation of chlorinated compounds through the enhanced reductive dechlorination (ERD) process is possible. ERD is the primary anaerobic biological process by which problematic chlorinated solvents such as tetrachloroethylene (PCE) and trichloroethene (TCE), dichloroethene (DCE) and vinyl chloride (VC) in groundwater are biologically transformed into less harmful end products such as ethene.

Key Benefits:

- Engineered, wide-area subsurface distribution mechanisms significantly reduce the number of injection points and events required.
- Three stage; immediate, mid-range and long-term controlled-release of lactic, organic and fatty acids for the steady production of hydrogen for optimized enhanced anaerobic biodegradation.
- High volume application optimizes contact with contaminants and reduces number of injection points required for treatment
- A viable, long-term source of staged-release hydrogen, on the order of 2-4 years from a single application
- Highly compatible with anaerobic bioaugmentation approaches using Bio-Dechlor INOCULUM PLUS

CHEMICAL REDUCING SOLUTION

CRS® (Chemical Reducing Solution) is an iron-based amendment for in-situ chemical reduction (ISCR) of halogenated hydrocarbon contaminants such as chlorinated ethenes and ethanes. CRS is a pH neutral, liquid iron solution that is easily mixed with 3-D Microemulsion Factory Emulsified before injection into contaminated groundwater.

Key Benefits:

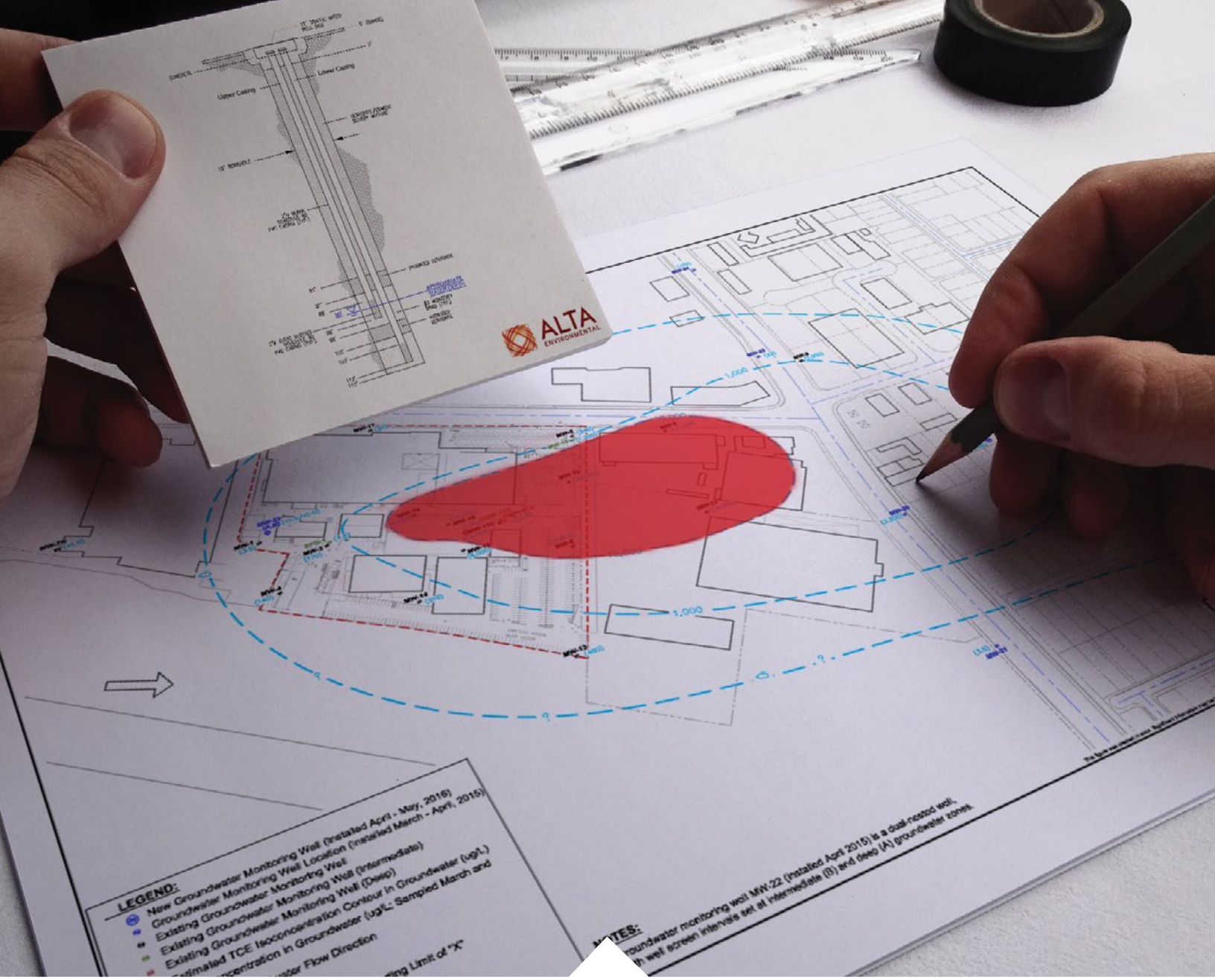
- Facilitates biogeochemical in situ chemical reduction (ISCR) of chlorinated contaminants
- Provides multiple pathways, both abiotic and biotic, for contaminant degradation in groundwater
- Contains a form of liquid iron which provides better distribution than can be achieved by directly injecting a solid iron material
- Seamless integration with anaerobic bioremediation
- Easy to apply with the electron donor 3-D Microemulsion

BIO-DECHLOR INOCULUM

Bio-Dechlor INOCULUM Plus (BDI Plus) is designed for use at sites where chlorinated contaminants are present and unable to be completely biodegraded via the existing microbial communities. BDI Plus is an enriched, natural microbial consortium containing species of Dehalococcoides sp. (DHC) which are capable of completely dechlorinating contaminants during in-situ anaerobic bioremediation processes.

Key Benefits:

- Rapid and effective treatment of undesirable anaerobic dechlorination intermediates such as dichloroethene (DCE) and vinyl chloride (VC)
- A low-cost means of enhancing the anaerobic biodegradation process
- Application can occur at almost any stage of a project, beginning, middle or end
- Highly compatible with a range of electron donors such as 3-D Microemulsion and HRC.
- Ease-of-application and handling

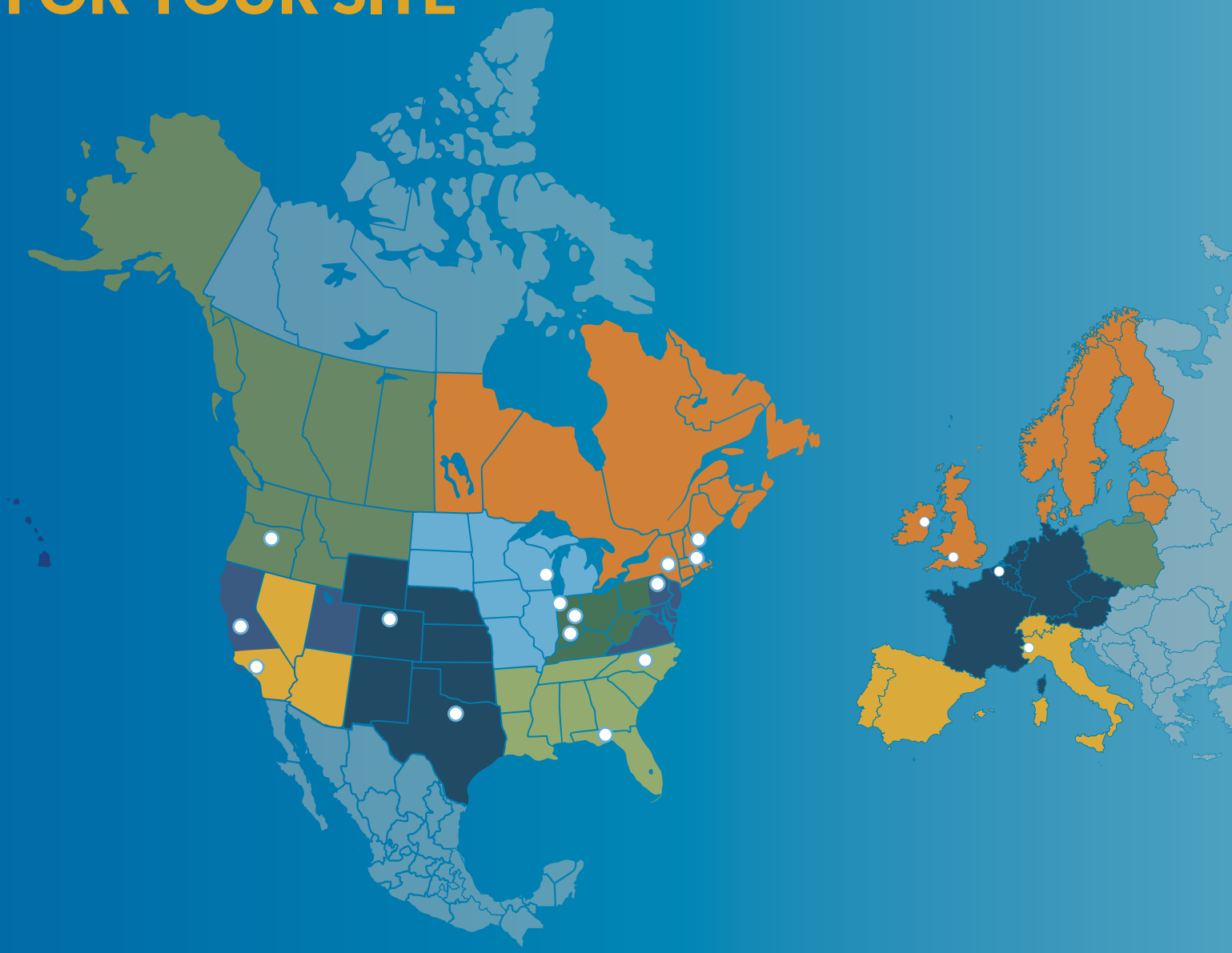


ABOUT THE ENVIRONMENTAL CONSULTANT

Alta Environmental is a full-service consulting firm specializing in subsurface remediation, air quality, building sciences, sustainability, water resources, and environmental health and safety compliance services. Alta is comprised of distinguished environmental engineers and professionals whose collective track record features decades of proven, budget-minded solutions to a full range of environmental and engineering needs. Alta is focused on providing high-level strategic and cost-effective solutions — both short- and long-term — for industrial, commercial and government clients.

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WE'RE READY TO HELP YOU
FIND THE RIGHT SOLUTION FOR YOUR SITE



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