Site Closure Using Low-Pressure Injection of Colloidal Activated Carbon – Overview and Case Study

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NEIWPCC 27th National Tanks Conference
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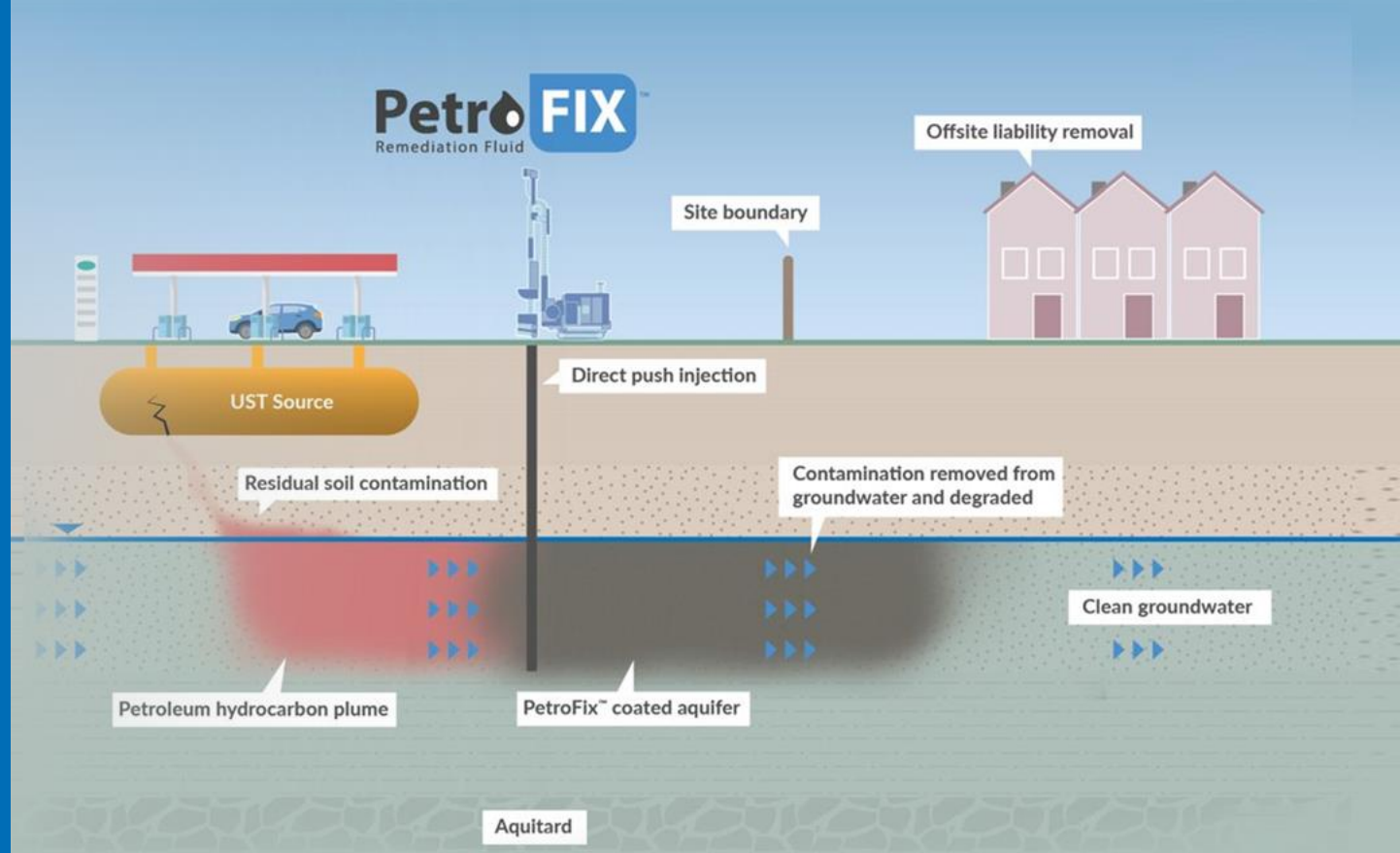
Agenda

- How the Technology Works
- Distribution
- Case Study
- Tyler Harris – *Importance of Application Methods For In Situ Micron Scale Carbon Injections* is “Part 2”



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PetroFIX® Remediation Fluid

Evolution of Activated Carbon For *In Situ* Hydrocarbon Remediation

- **Colloidal Activated Carbon (CAC, 1-2 µm ∅) suspension, +30%**

  Wet milled and shipped as viscous remedial fluid in totes or drums

- **Slow and rapid release water-soluble electron acceptors that flow with the CAC (NO_3 and SO_4)**
- **Only commercial AC product that allows you to design and apply on your own**

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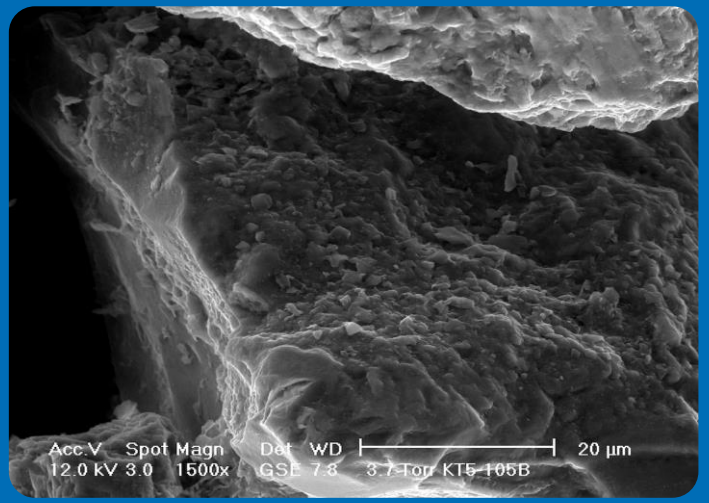
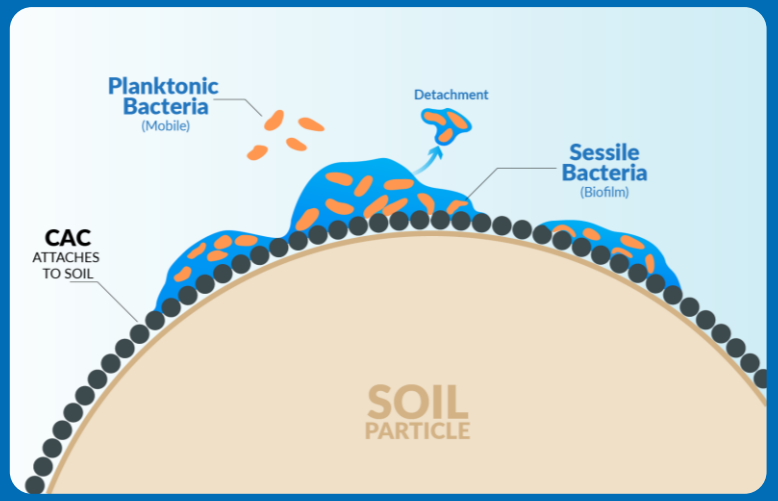
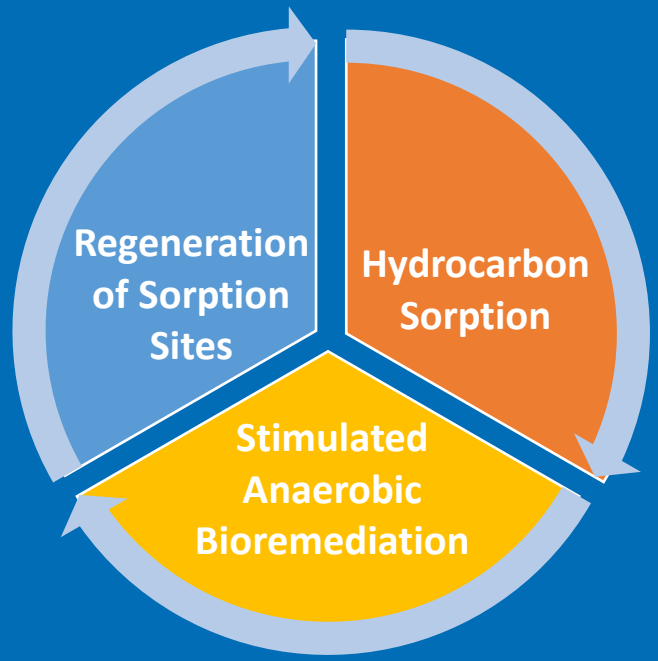
Dual Approach: Adsorption + Biodegradation

- PetroFix coats soils in flux zones with a micrometer thick layer
- Longevity – flux from upgradient or back-diffusion captured over time
- NO_3 + SO_4 kick-start bioremediation = biofilm formation
- *In situ* carbon regeneration = contaminant destruction and > longevity







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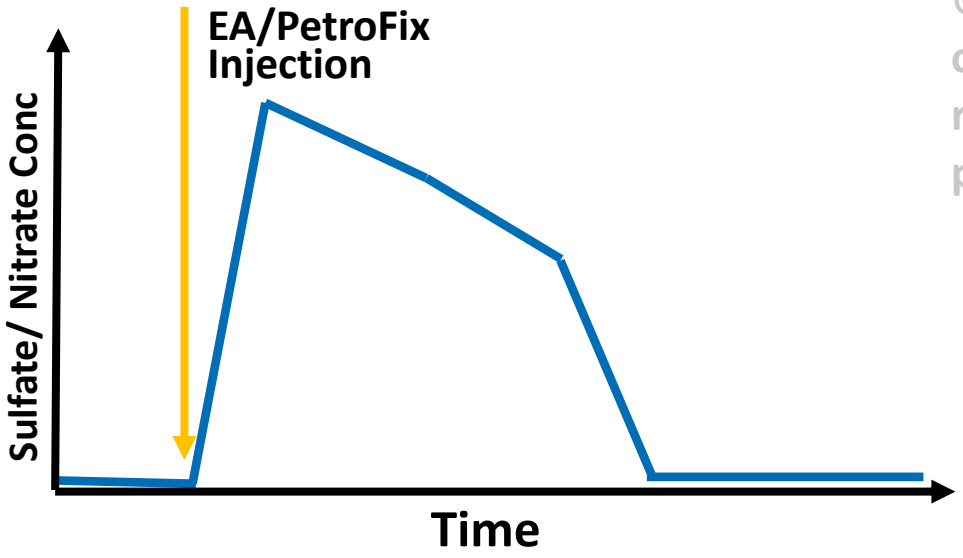

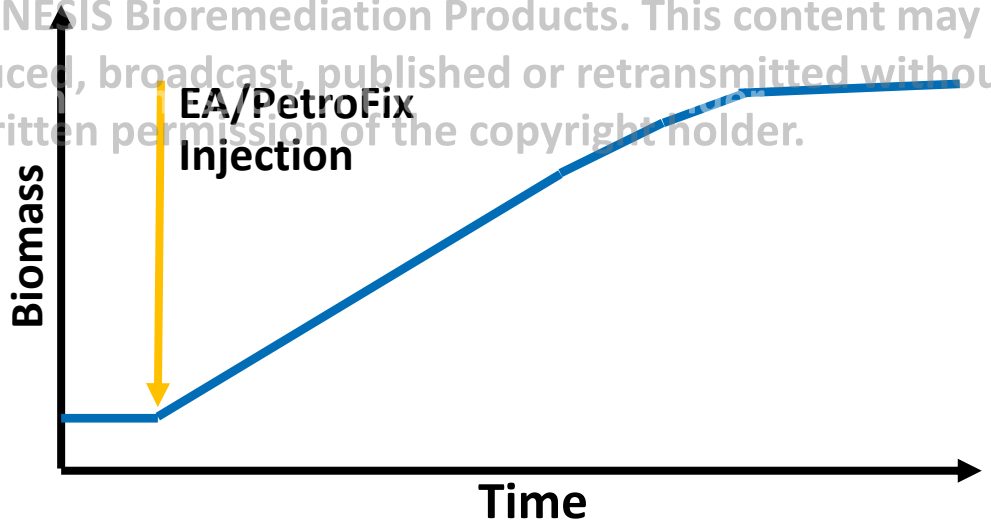

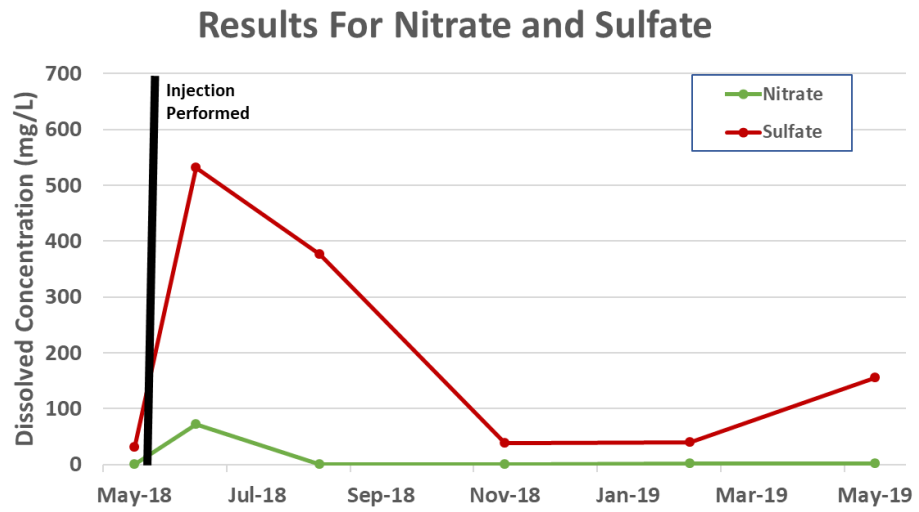

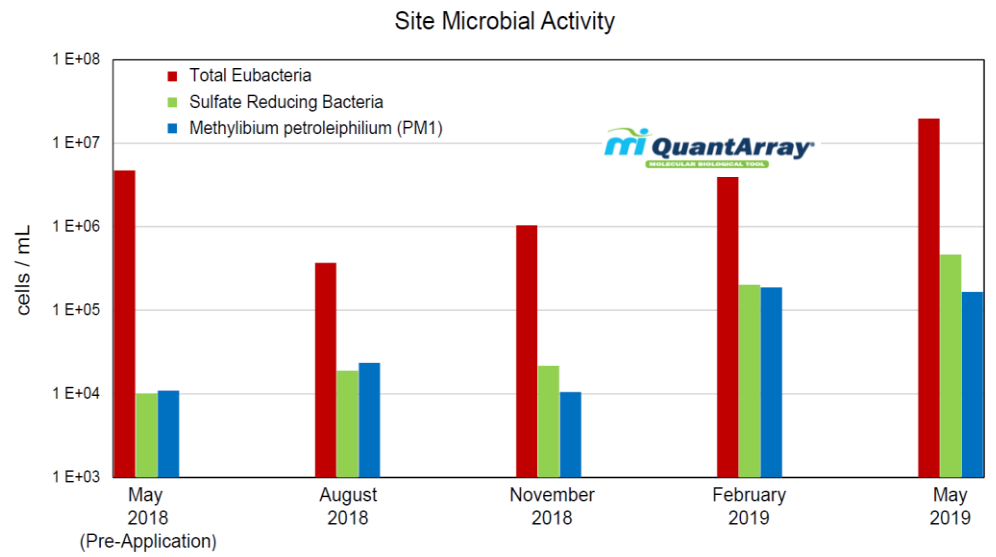

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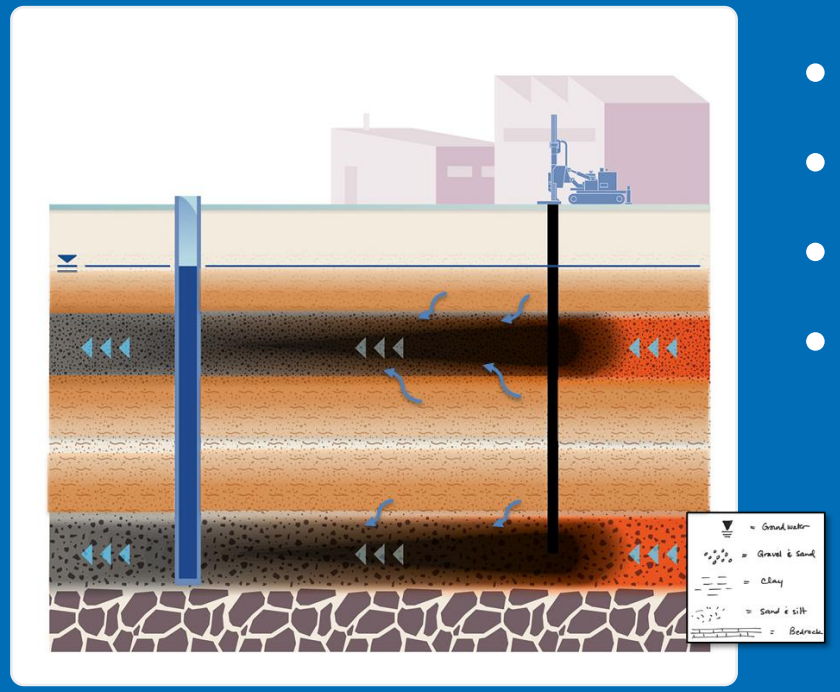
Untreated Flux Zones Create Greatest Risk



- Dictates plume size and shape
- Allow for off-site migration
- Back diffusion exacerbates problem
- Multiple flux zones create a challenge
  - Incomplete coverage leaves plume intact

How does CAC solve this problem?

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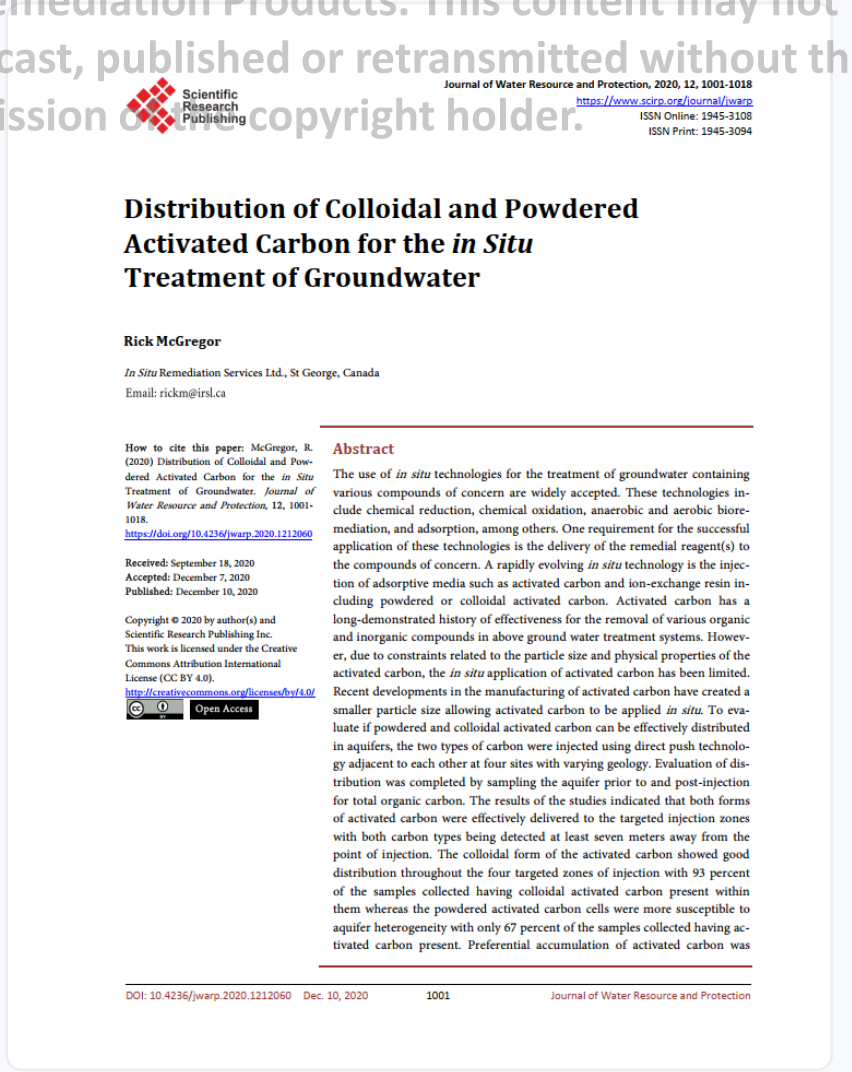
Low-Pressure Injection Research

CAC vs PAC Distribution Study

- 4 sites, two 10x10m test cells each – 8 plots
- ~65 soil samples per plot to find AC (520 total)



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Distribution of Colloidal and Powdered Activated Carbon for the *in Situ* Treatment of Groundwater

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Abstract

The use of *in situ* technologies for the treatment of groundwater containing various compounds of concern are widely accepted. These technologies include chemical reduction, chemical oxidation, anaerobic and aerobic bioremediation, and adsorption, among others. One requirement for the successful application of these technologies is the delivery of the remedial reagent(s) to the compounds of concern. A rapidly evolving *in situ* technology is the injection of adsorptive media such as activated carbon and ion-exchange resin including powdered or colloidal activated carbon. Activated carbon has a long-demonstrated history of effectiveness for the removal of various organic and inorganic compounds in above ground water treatment systems. However, due to constraints related to the particle size and physical properties of the activated carbon, the *in situ* application of activated carbon has been limited. Recent developments in the manufacturing of activated carbon have created a smaller particle size allowing activated carbon to be applied *in situ*. To evaluate if powdered and colloidal activated carbon can be effectively distributed in aquifers, the two types of carbon were injected using direct push technology adjacent to each other at four sites with varying geology. Evaluation of distribution was completed by sampling the aquifer prior to and post-injection for total organic carbon. The results of the studies indicated that both forms of activated carbon were effectively delivered to the targeted injection zones with both carbon types being detected at least seven meters away from the point of injection. The colloidal form of the activated carbon showed good distribution throughout the four targeted zones of injection with 93 percent of the samples collected having colloidal activated carbon present within them whereas the powdered activated carbon cells were more susceptible to aquifer heterogeneity with only 67 percent of the samples collected having activated carbon present. Preferential accumulation of activated carbon was

McGregor, R.(2020) Distribution of Colloidal and Powdered Activated Carbon for the in Situ Treatment of Groundwater. Journal of Water Resource and Protection, 12, 1001-1018.

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Low-Pressure Injection Research

CAC vs PAC Distribution Study

- 4 sites, two 10x10m test cells each – 8 plots
- ~65 soil samples per plot to find AC (520 total)

CAC - detected in 94.4% of samples
PAC - detected in 42.4% of samples

CAC - homogeneous distribution
PAC - thin fracture distribution

PAC - enriched well packs, +224% mean TOC
CAC - no pack enrichment, -35% mean TOC

CAC PAC

Horizontal

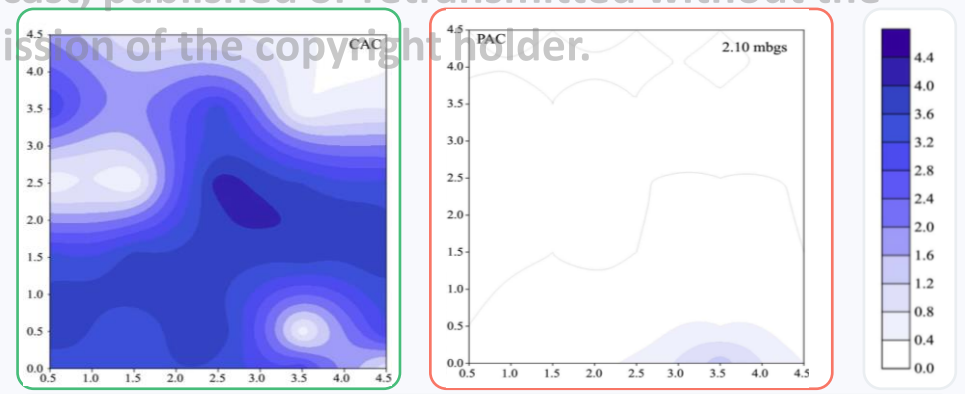
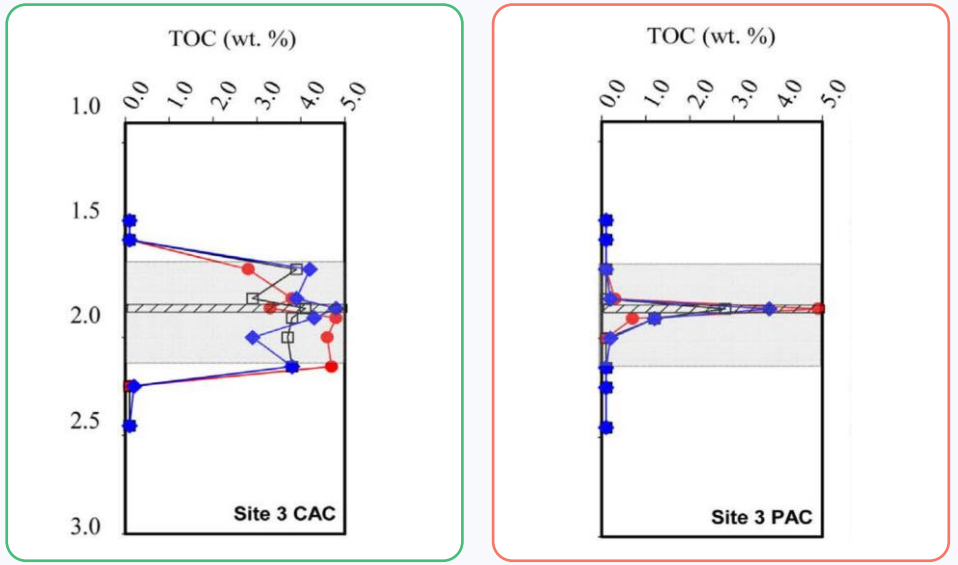


Figure 5. Total organic carbon (TOC) plots for the PAC and CAC test cells at Site 3 following the injection of the CAC and PAC at various depths (1.70, 1.85 and 2.10 mbgs).

Vertical



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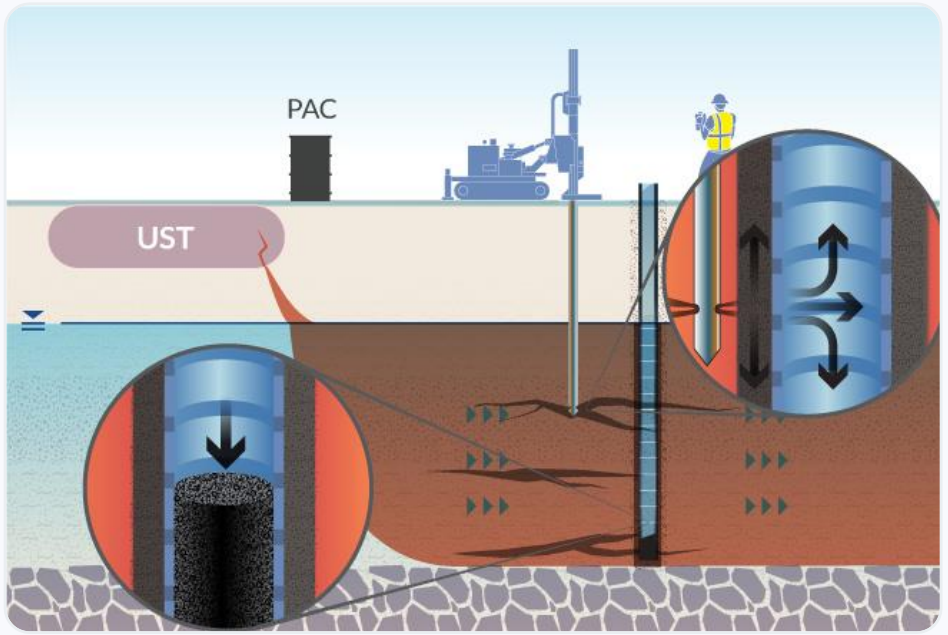
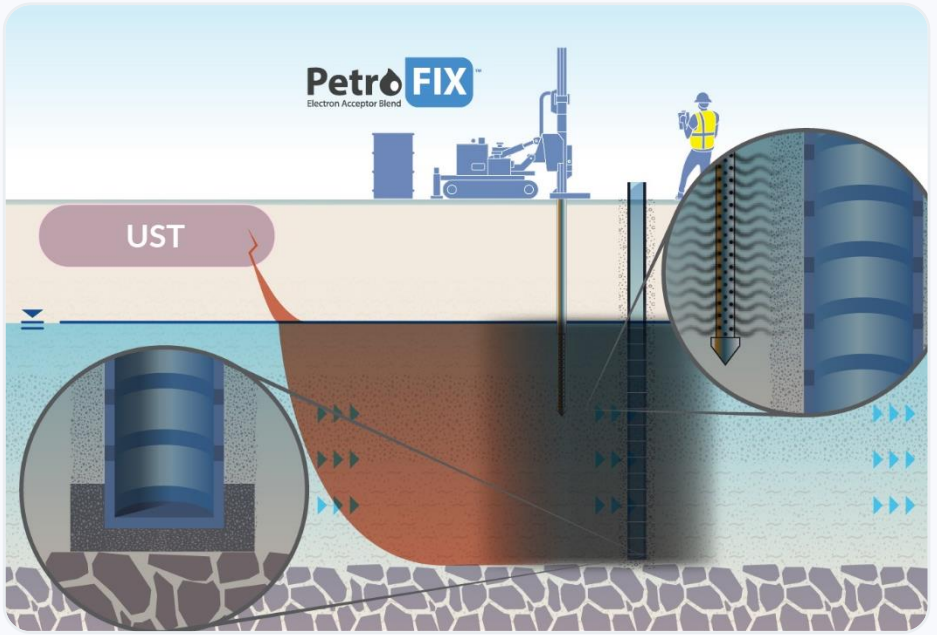
Illustrated distribution comparison of PAC vs CAC

PAC



PAC pressure averaged 235 psi
well enrichment and fractures

CAC



CAC pressure averaged 36 psi
no well enrichment, no fractures
Superior flux zone coverage

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Easy To Apply CAC Opens Other Options:

In Situ Spill Response And Excavation Polish

Pipeline Utility Corridor Floods

UST Basin Floods

Remediation and/or Prevention

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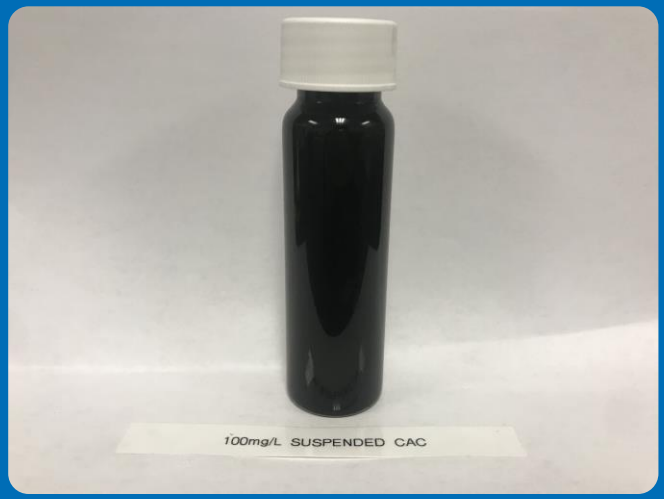
Let’s Make Contact!

Proper Spacing → Proper Volume → Proper Contact
Use CAC as field tracer (see in water or soil cores)



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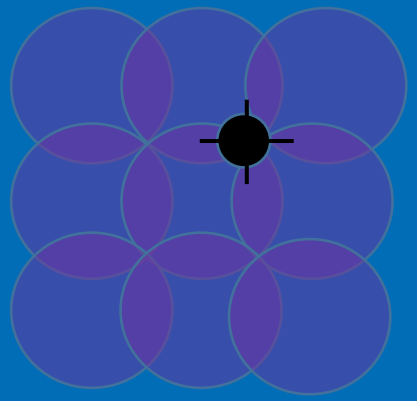

Monitoring well CAC Injection Point

Recommended starting spacing:
5 to 6.5’ on center

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Case Study: Former UST Site

- 1976-1992: Site operated as a retail gas station in Denver metro area
- Underground storage tank (UST) leak led to large off-site plume
- Heterogenous clay, silt, sand

CGRS SOLUTIONS DELIVERED

Monica Young
Ft Collins, CO

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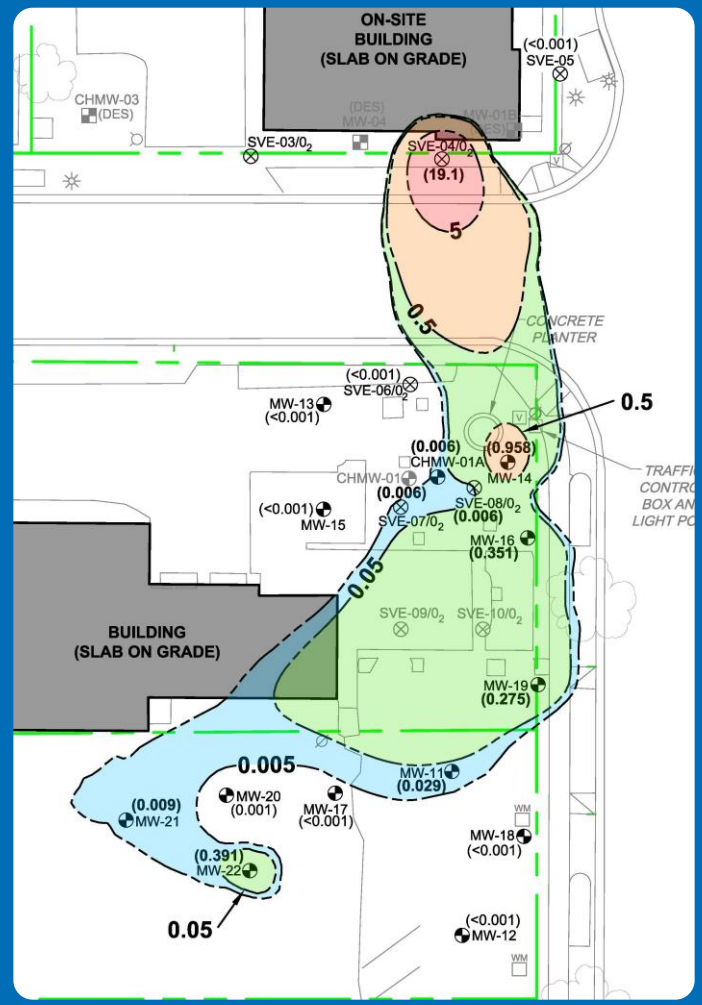
Previous Remediation Strategies (2004-2017)

- Remediation History:
  - SVE(1,550 lb hydrocarbon removed)
  - Limited excavation (850 cy)
  - SVE again with oxygen diffusion (5,500 lb removed)
  - PAC injection
  - ISCO + oxygen release
- Extent and magnitude of benzene plume remained above closure levels (6,000 ft²)



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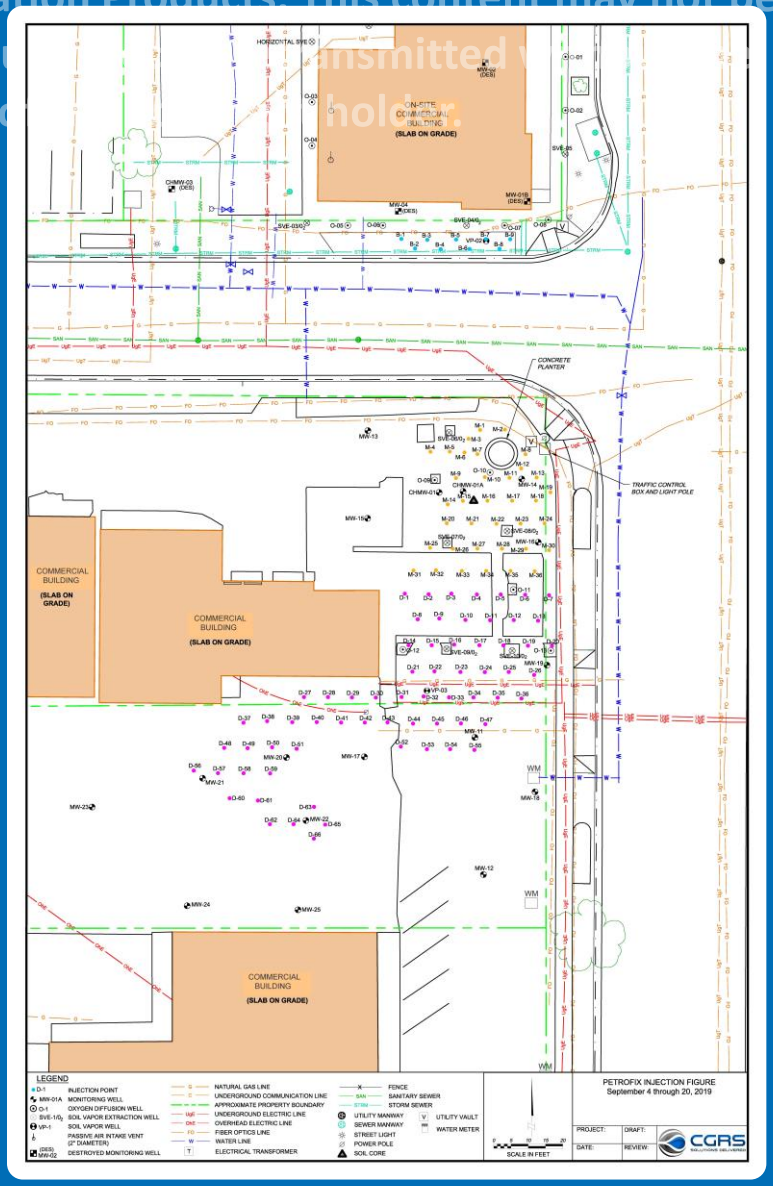
Shift Gears

Concerns of performance and rebound led to re-evaluation and selection of the CAC over 2nd round of ISCO



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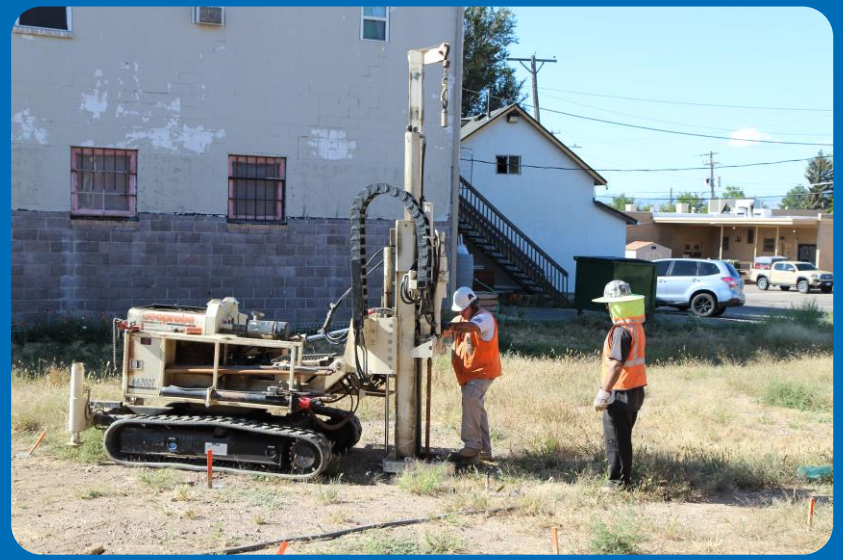
PetroFix Application

- Completed in September 2019
- 29,600 lb PetroFix
- 1,480 lb Electron Acceptor Blend
- 20,000 gallons applied
- 111 injection points
- Low injection pressures (<40 psi)



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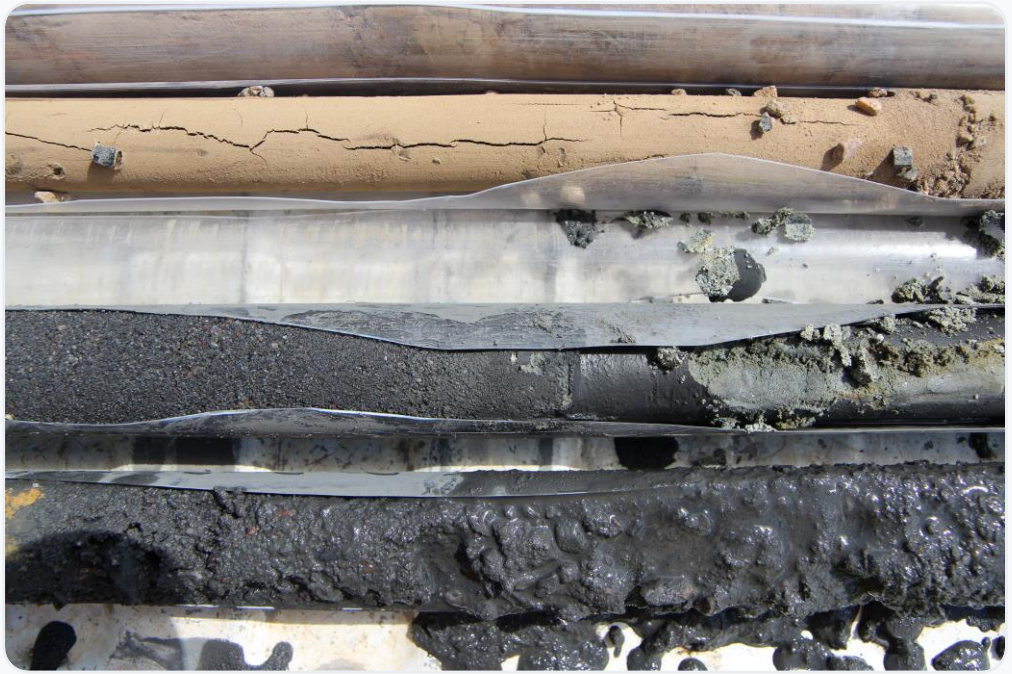
PetroFix Used As Tracer to Optimize Application

- Lack of detections allowed field crews to adjust pressure, volumes, or spacing to cover “flux” zones
- When PetroFix observed in wells or soils cores then full-scale proceeded
- **Key to remedial success**



Soil core collected across the injection interval (bottom 2 core samples) showing successful distribution in sandier flux zones.

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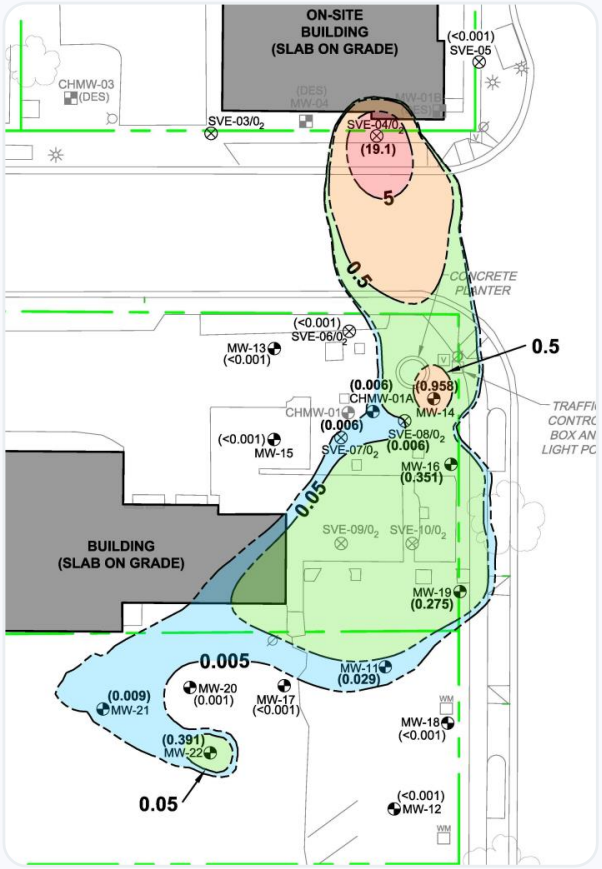
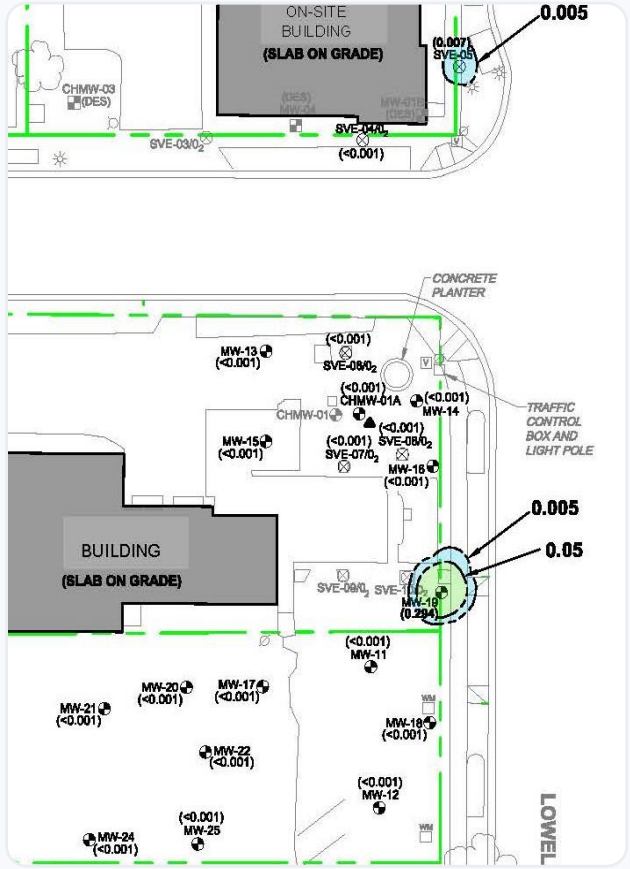
Results - Benzene

Benzene Plume Extents Before and After Application



Pre-Application



11 Months Post-Application

Key:

- >5 µg/L
- >100 µg/L
- >1,000 µg/L

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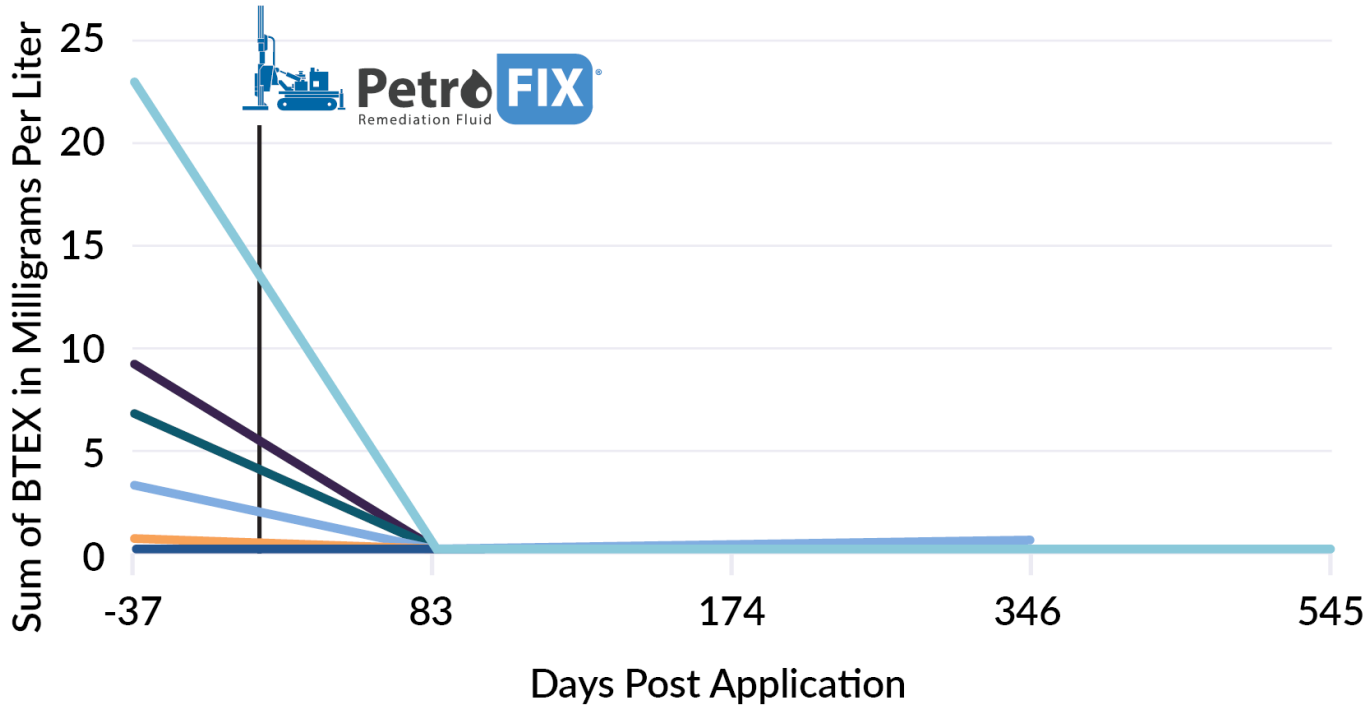
Results – BTEX (NFA Achieved)

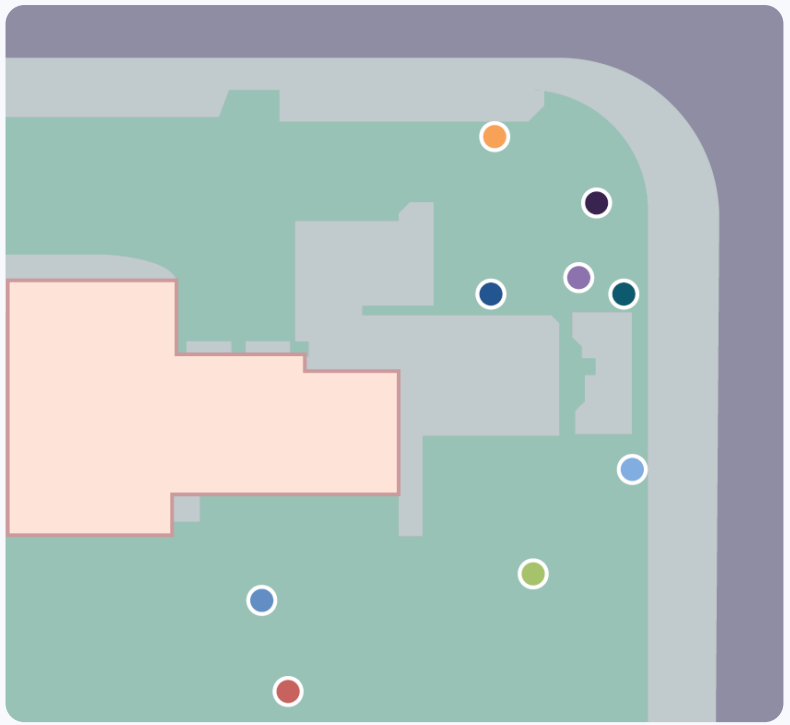
BTEX Performance in Monitoring Wells

Monitoring events 2, 6, 11, 18 months post-application



Key:

MW-11 MW-14 MW-16 MW-19 MW-20
MW-22 SVE-08 SVE-04 SVE-06 SVE-07



9 of 10 wells below standards for 18 months
Single well (MW-19) slight rebound above 10 µg/L

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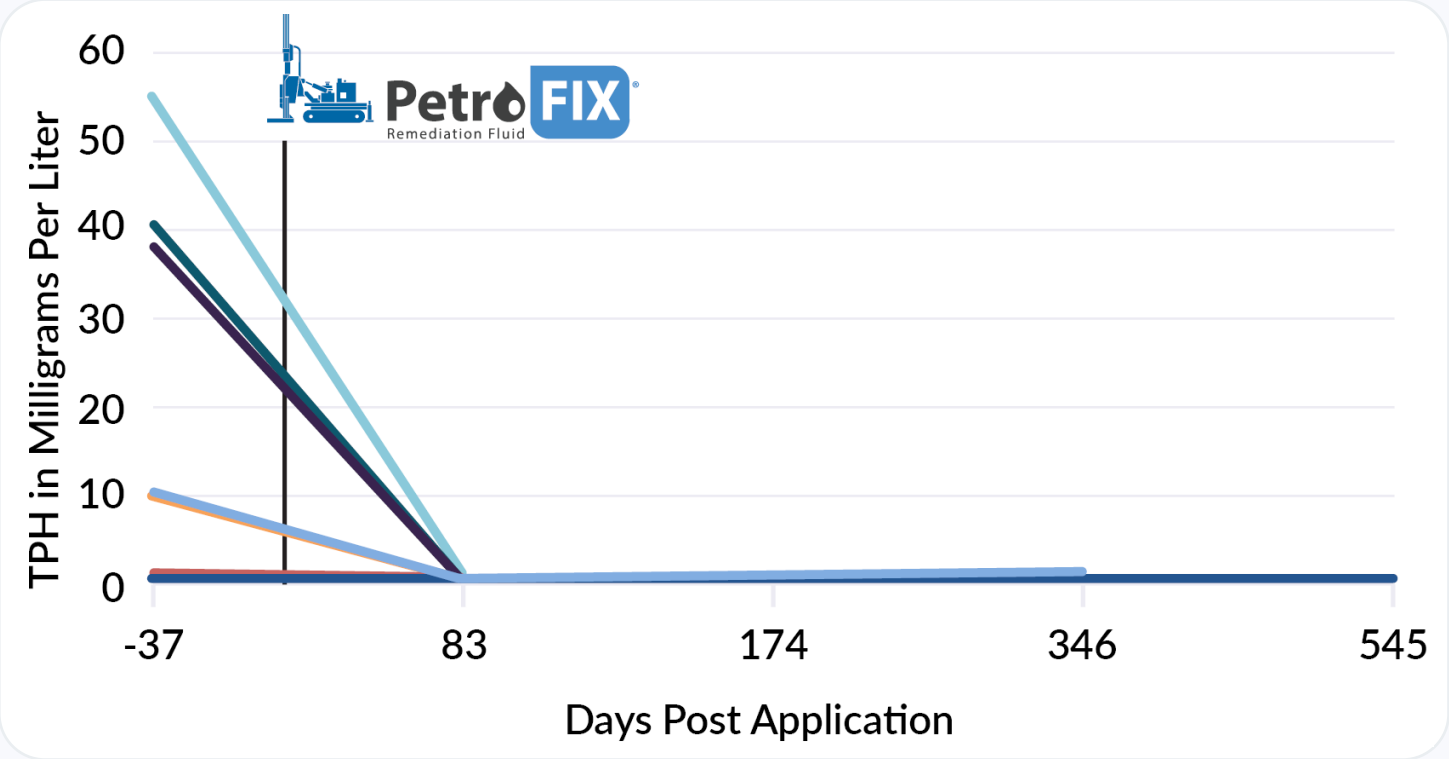
Results – TPH G (NFA Achieved)

TPH Performance in Monitoring Wells



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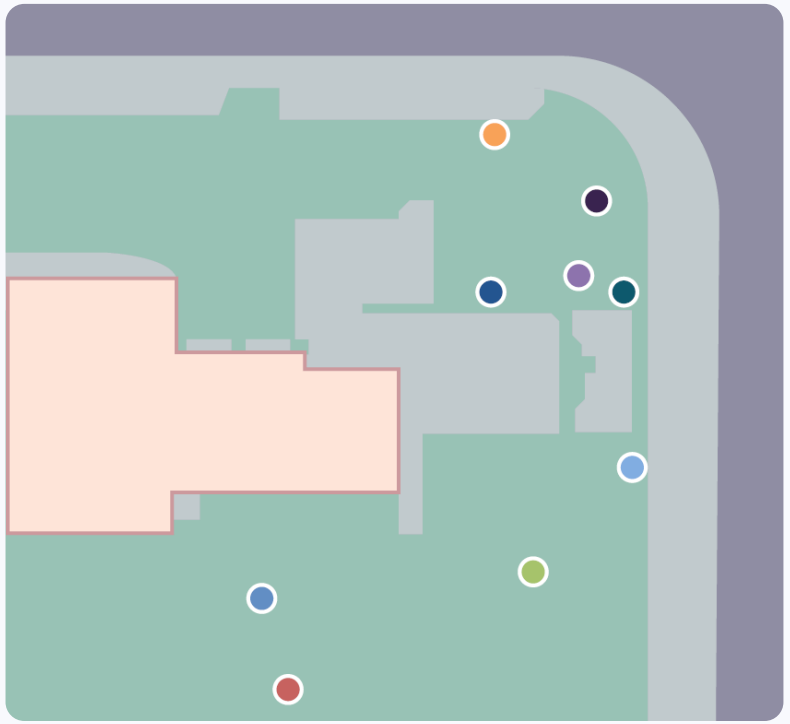

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Single well (MW-19) slight rebound above 10 µg/L

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Thank You!

Todd Herrington
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