



## **EHC<sup>®</sup> Plus:**

**Securing rapid contaminant reduction and accelerated  
bioremediation using an  
activated carbon-based injectable reagent**

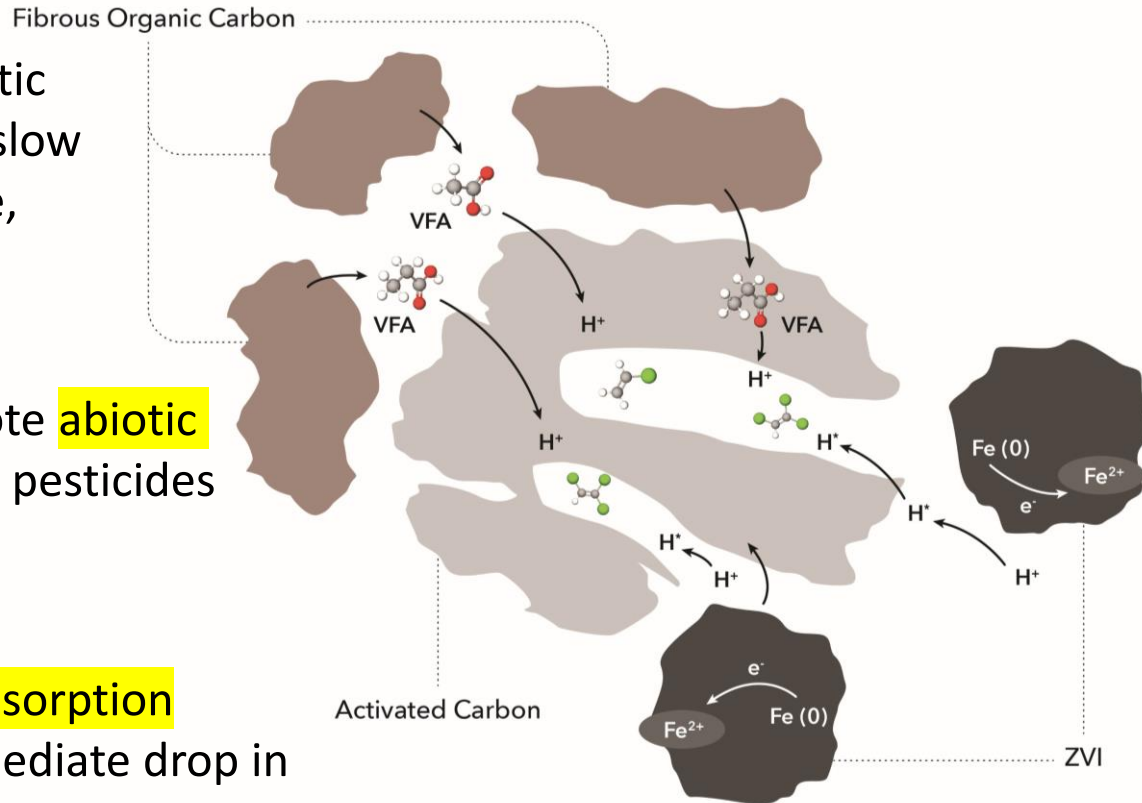
# Activated Carbon (AC) Technology

- Activated Carbon based technology applies a mixture of AC complemented with chemical and/or biological amendments for in-situ remediation.
- The AC adsorption pathway can result in rapid decrease of dissolved phase CoC concentrations and reduce mass flux off-site, if contact is established.
- Destructive pathways are critical for overall treatment, because the ideal long-term goal is to destroy target CoCs, whilst using AC as a complementary adsorption pathway.
- The destructive pathway best shown by chloride generation when treating CVOCs. However, environmental molecular diagnostic (EMD) tools can provide secondary lines of evidence.

# EHC Plus:

## Destructive power of EHC ISCR reagent, *plus* adsorptive ability of PAC for long term treatment and polishing

- EHC Plus reagent is a synergistic mixture of micro-scale ZVI, a slow release organic carbon source, and 15% (wt) PAC
- ZVI and organic carbon promote abiotic / biotic degradation of cVOCs, pesticides and organic explosives
- PAC provides an additional adsorption pathway - resulting in an immediate drop in aqueous contaminants, while ISCR conditions are established and a dynamic treatment zone is created



# Key Benefits

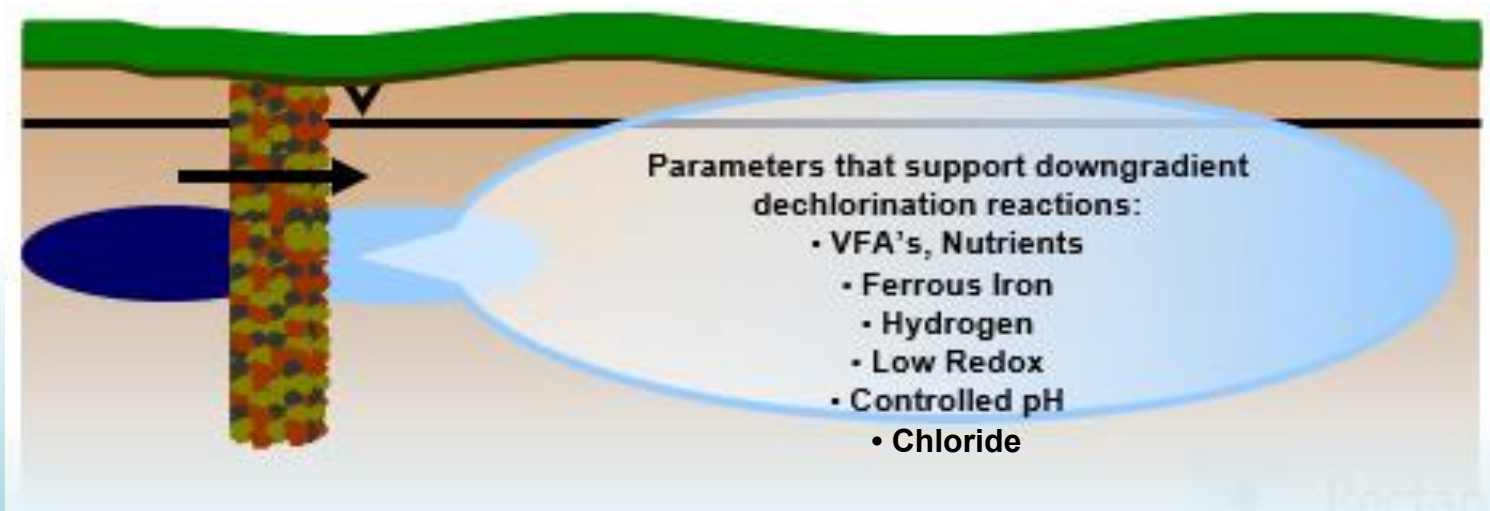
1. Multiple and dynamic reaction pathways → abiotic, biotic, adsorptive
2. Abiotic and biotic pathways destroy contaminants, including those with lower adsorption affinity for activated carbon, such as vinyl chloride, chloroethanes, and dichloroethanes
3. Synergistic organic carbon and ZVI mixture creates a “reactive halo” in the Downgradient Zone thru VFAs and soluble Fe corrosion products
4. Solid PAC stays in the Injection Zone and does not migrate with groundwater flow - cutting off contaminant plumes and helping achieve low remedial goals

Chemical name	CAS-No	Weight %
Iron	7439-89-6	15-40
Organic amendment	Proprietary	44-70
Soybean oil	8001-22-7	1.7
Activated carbon	7440-44-0	10-15
Viscosity modifier	Proprietary	0-5

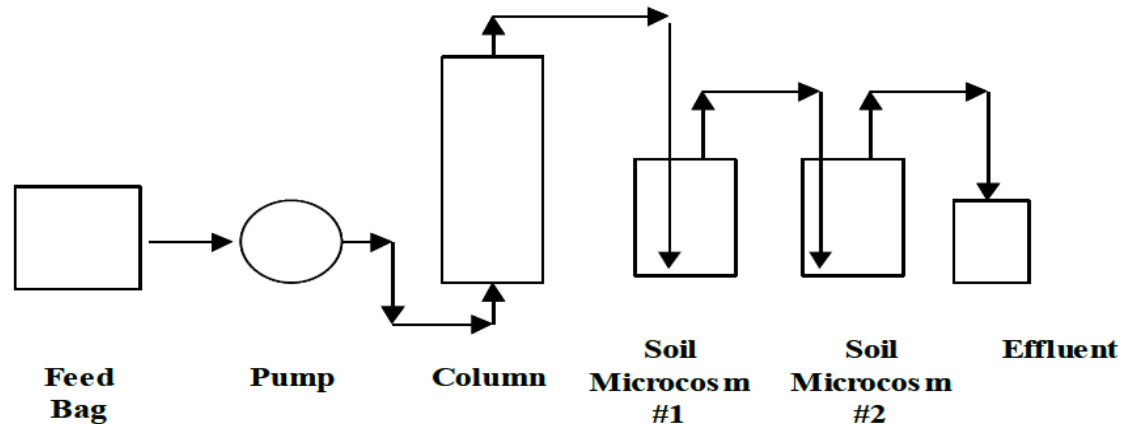
# EHC Plus - Downgradient Effects

Zone of influence typically exceeds direct placement zone, in downgradient direction

- Elevated levels of TOC, ferrous iron, reduction in ORP, buffered pH
- Measured up to 20 m away – dependent upon GW flow velocity



# Bench-Scale Data for CVOC Treatment with EHC Plus

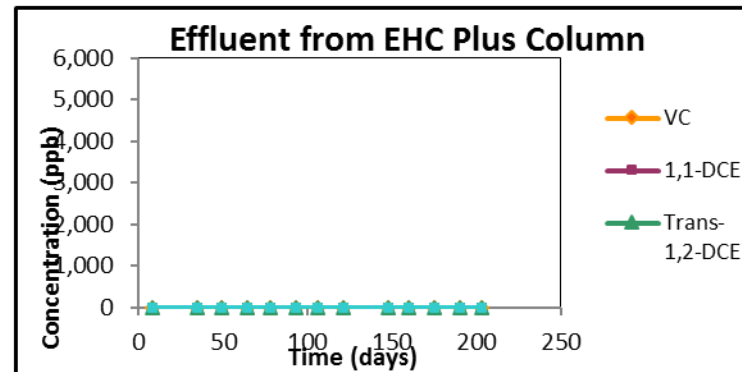
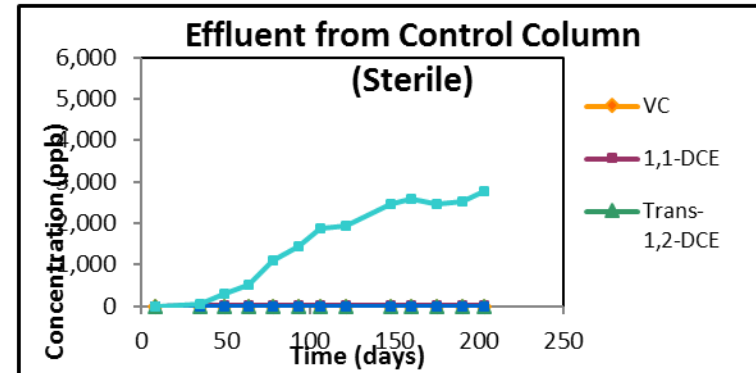
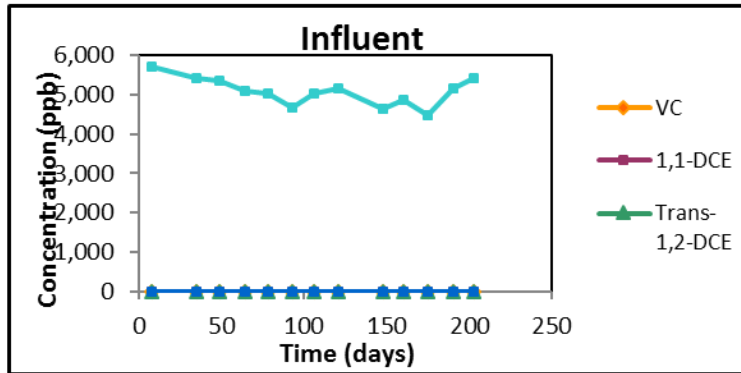


**Figure 1:** Schematic of experimental set up. The peristaltic pump transfers feed water from a collapsible Teflon bag into the bottom of the column. Effluent from the column flows through soil microcosm #1 and then soil microcosm #2.

**Table 1: Column Study Details.**

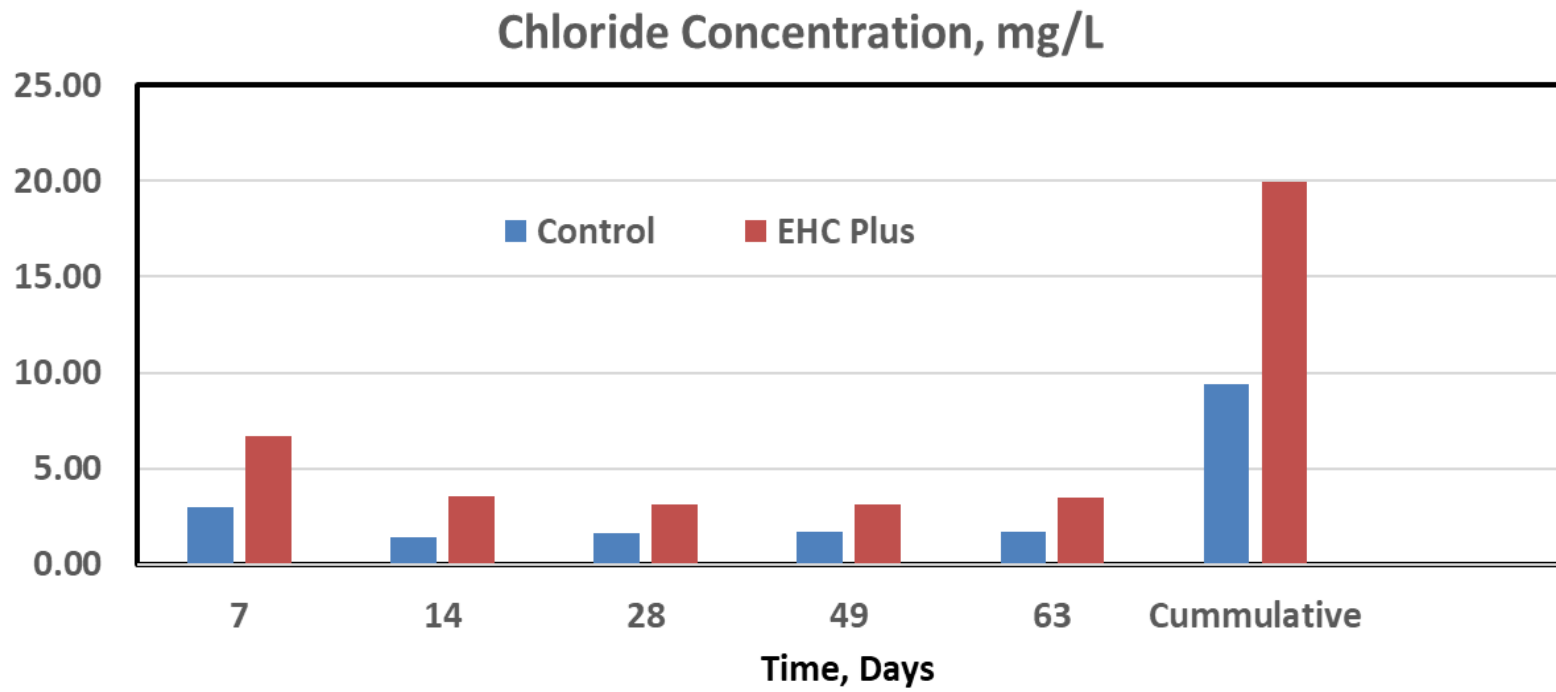
Flow rate per column:	55	mL/day
Influent TCE concentration in groundwater	~5,000 to 6,000	µg/L
Column diameter:	5.2	cm
Column length:	50	cm
Column volume:	1,062	cm <sup>3</sup>
Assumed porosity within column	200	cm <sup>3</sup>
Calculated contact time:	3.6	days

# Bench-Scale Data for CVOC Treatment with EHC Plus



- Feed water to columns only had TCE.
- Effluent from the sterile Control shows that most TCE is breaking through, as one would expect, and no daughter products are formed.
- Effluent columns show that neither TCE nor the daughter products are coming off. Perceived as complete removal by physical adsorption to PAC.

# Release of chloride indicates that CVOCs are being treated with EHC Plus





# EHC Plus - Installation Methods

- Injection of slurry via Direct Push Technology (DPT)
- Hydraulic or Pneumatic Emplacement (for fine-grain formations including clay, weathered and fractured bedrock)
- Direct Placement into open excavations or Trench PRBs
- Deep soil mixing



# EHC Plus - Case Study, Confidential Site USA

## Site Background

- Former manufacturing facility where operations ceased in 1990s.
- TCE distributed via sub-grade piping to pits used for degreasing.

## Site Hydrogeology

- 7.5 m of fill placed above former canal.
- >60 m of sand and gravel deposits with till lenses and aquitards.
- GW seepage velocity is 0.2 m/day.

## Key Findings

- TCE in soil gas at property boundary as high as 176,000  $\mu\text{g}/\text{m}^3$
- TCE in source area soils up to 280 mg/Kg in the fill material.
- Highly oxic aquifer; no degradation products present
- Maximum TCE in groundwater up to 5.5 mg/L in source area.
- Plume migrating E/SE away from the river, across road and into residential area.

## Remediation Objectives:

- Prevent off-site migration of CVOCs
- Treat portion of the off-site plume and eliminate exposure to down-gradient receptors.

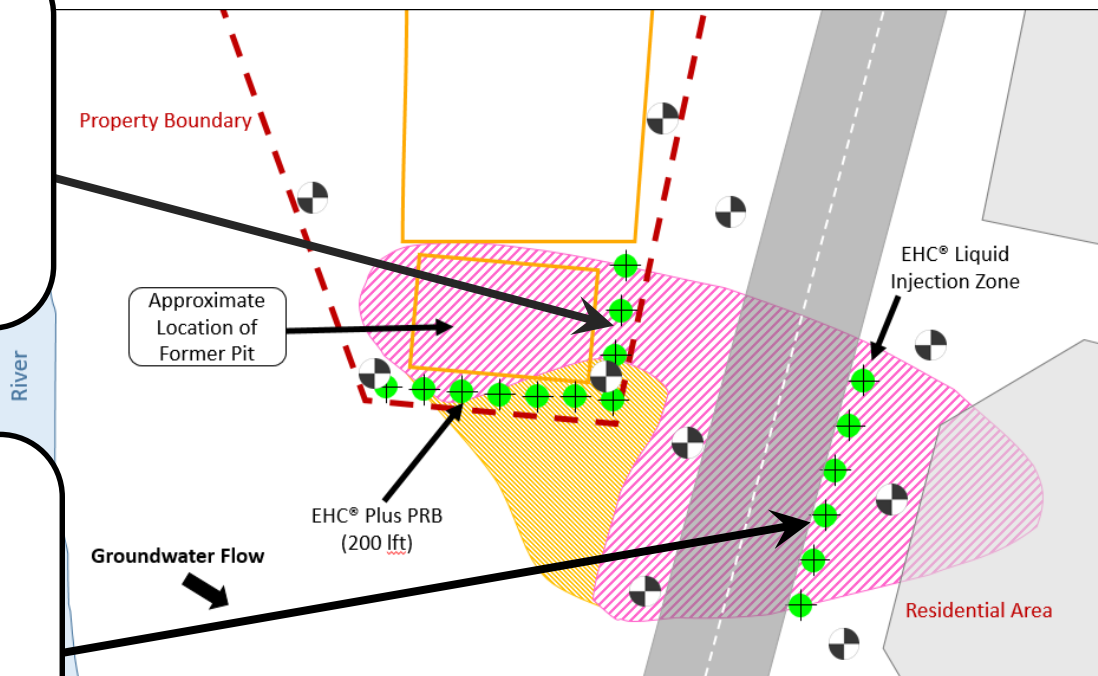
# Remedial Approach

## EHC Plus - Permeable Reactive Barrier

- 10,000 Kg into 10 IPs
- 40 L of Dhc culture
- Treatment of CVOCs via **physical, chemical and biological** pathways

## EHC Liquid - Reactive Zone

- 10,000 Kg into 6 IPs
- 18 L of Dhc culture
- Treatment of CVOCs via **biological and abiotic** pathways

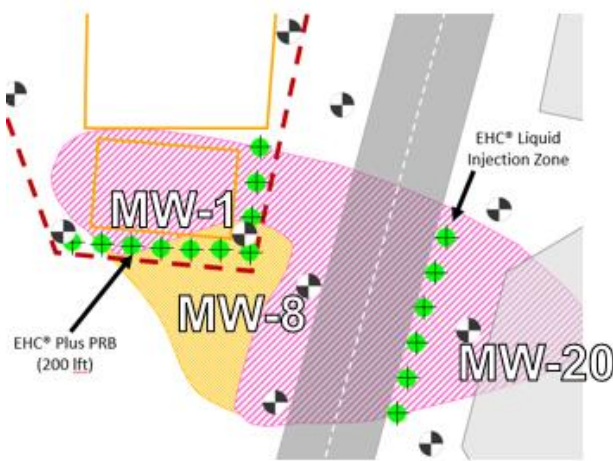


## Environmental Molecular Diagnostics (EMDs) used

- Molecular Biological Tools (MBTs)
- Compound Specific Isotope Analysis (CSIA)

# One Year Performance Monitoring Results

- Pre-Injection Feb 2017
- Post-Injection in Feb 2018



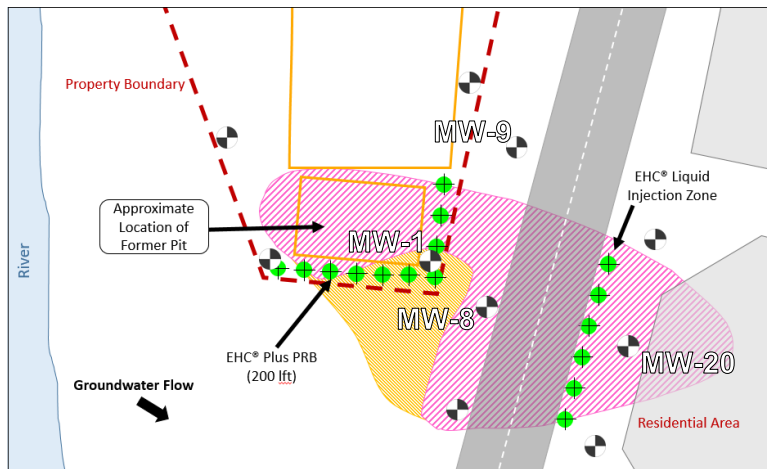
	In the EHC Plus PRB		Downgradient of the EHC Plus PRB		Downgradient of the EHC Liquid Reactive Zone	
	MW-1		MW-8		MW-20	
	Pre	Post	Pre	Post	Pre	Post
ORP, mV	126	➔ -399	125	➔ -344	132	➔ -362
Sulfate, mg/L	99.8	➔ 16.4	133	➔ <10	78	➔ 21
VFAs, mg/L	<0.10	➔ 103.2	<0.10	➔ 59.9	<0.10	➔ 0.26
DHC, cells/ml	5.7E+02	➔ 1.6E+05	<5.0+01	➔ 3.9E+06	<5.0+01	➔ 3.0E+04
TCE, mg/L	0.13	➔ <0.005	0.038	➔ <0.005	0.26	➔ <0.005
Cis-DCE, mg/L	<0.005	➔ 0.04	0.004	➔ 0.072	0.0037	➔ <0.005
VC, mg/L	ND	➔ 0.019	<0.002	➔ 0.022	<0.002	➔ 0.042
Ethene, mg/L	<0.0001	➔ 0.016	<0.0001	➔ 0.032	<0.001	➔ 0.002

## Confirmation of Degradation Occurring

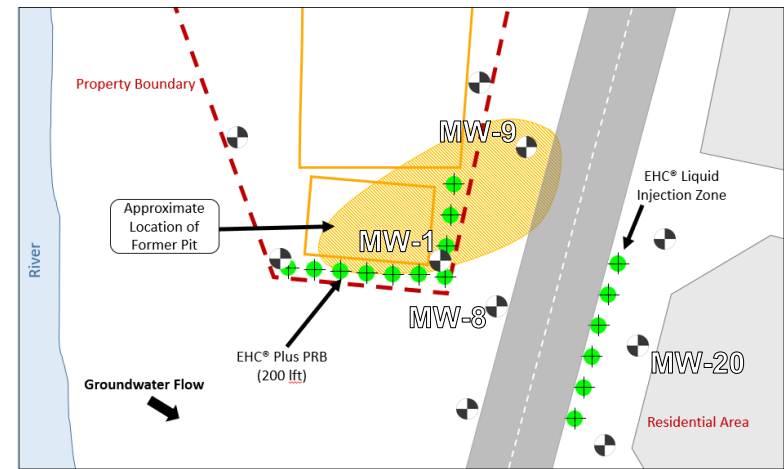
- All key indicators indicating expected trends
- CSIA lines of evidence
- MBT's: increase in Dhc population
- Formation of daughter products

# Plume Response EHC Plus & EHC Liquid Injections

Feb 2017



Feb 2018



## Expected Continued Site Treatment

- EHC Plus PRB: 5 - 10 years
- EHC Liquid Reactive Zone: 2 - 4 years

- ✓ Prevent off-site migration of CVOCs
- ✓ Treat portion of off-site plume and eliminate exposure to down-gradient receptors
- ✓ 72% Mass Removal from combined remedy after one year of treatment

# Summary & Conclusions

- 1) Highly aerobic aquifer turned anaerobic and reducing in 12 months.
- 2) Plume pulled back from the property line and off-site migration of TCE was prevented.
- 3) Post-injection geochemical parameter changes, MBTs and CSIA indicate that chemical and microbiological treatment of TCE and daughter products occurred in wells MW-1 / MW-8, under the influence of EHC Plus.
- 4) Concentration of Dhc increased by several orders of magnitude in key wells, under the influence of EHC Plus and EHC Liquid.
- 5) EHC Plus / EHC Liquid combined remedy met site-specific remedial objectives.



# EHC Plus - Applications

- **Permeable Reactive Barriers (PRBs) for Plume Control:**  
EHC Plus has an estimated lifetime of 5 to 10 years in the subsurface, making it ideal for placement into PRBs to treat CVOCs under flow-through conditions.
- **Hot Spot Applications:** EHC Plus can be used for Source Area treatment, where the product's adsorptive capability and longevity allows for continued treatment of contaminants – as they slowly back diffuse from the solid matrix to groundwater (typically observed at sites with high concentrations of sorbed mass / NAPL).
- **Plume Treatment:** Designs with multiple reactive zones along the plume, for cost effective treatment of large dilute plumes.

## Key Attributes:

Abiotic & Biotic  
Degradation

Adsorptive  
capabilities

pH Balanced

Long lasting

Field proven

Quickly generates  
reducing conditions

Minimal generation of  
intermediates

***Kiitos huomiostasi !***



For more information:

Mike Mueller (Austria)

[mike.mueller@peroxychem.com](mailto:mike.mueller@peroxychem.com)

+43 664 1803060

**Soil & Groundwater Remediation - EMEA**

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