# A Dispersive Colloidal Activated Carbon Technology Platform for Securing Speed and Certainty in Groundwater Remediation

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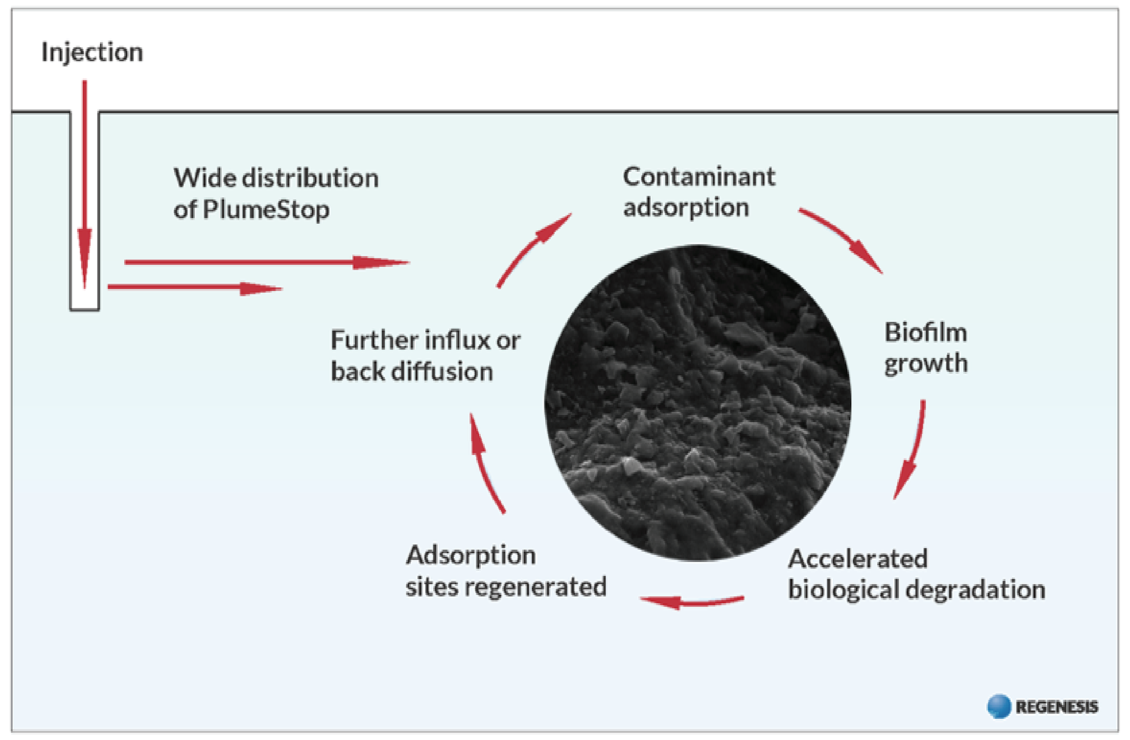
## Introduction

PlumeStop® Liquid Activated Carbon™ is a platform technology designed to bring speed and certainty to bioremediation. Through its unique ability to be dispersively emplaced into a formation, it can be flowed into the subsurface at low pressure, 'painting' a micron-layer coating of activated carbon onto the soil particles. Once emplaced, these particles adhere strongly forming a permanent addition to the soil.

The activated carbon particles rapidly sorb groundwater contaminants, eliminating the dissolved-phase plumes into which they are emplaced, and capturing further influx of contaminants that may be migrating from up-gradient or back-diffusing out of lower permeability zones. The emplaced material provides an ideal surface for microbial colonization and growth. This is due to the rough surface of the activated carbon and to the presence of the captured contaminants which remain available to the bacteria for biodegradation. Colonization by contaminant degrader species is therefore favored.

A dynamic synergy is established. The carbon captures diffuse contamination from the groundwater, increasing the local abundance of the contaminant to the degrading bacteria living on and among the carbon particles. The bacteria then degrade the captured contaminants, restoring the carbon's capacity for further contaminant capture. Contaminant destruction therefore proceeds while the groundwater is kept clean. PlumeStop is typically applied with compatible controlled-release electron donors electron acceptors to ensure conditions appropriate for biodegradation of the sorbed contaminants are maintained. It may also be used as a standalone treatment when natural attenuation conditions are adequate.




PlumeStop usage schematic


PlumeStop Liquid Activated Carbon

## Case Study – Midwest Manufacturing Facility

### Site Details

**Site Type:** Former electronics facility

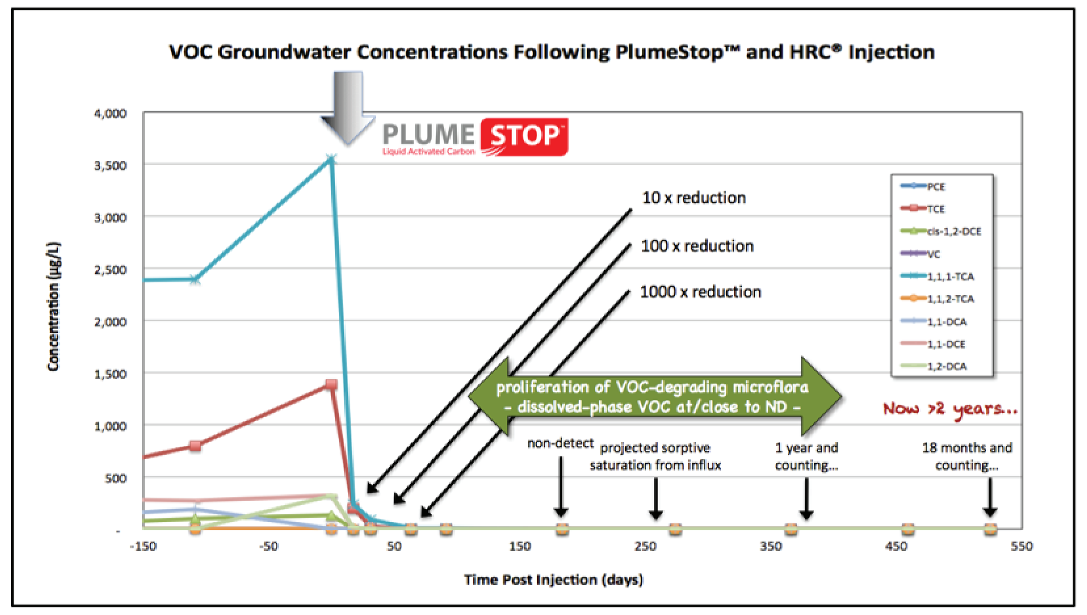
**Contaminant of Concern:**
TCE 1,390 µg/L
TCA 3,550 µg/L

**Soil Type:** Sand to silty-sand

**Depth to Groundwater:** 10 – 13 ft
**Seepage Velocity:** 12 ft/yr to the southwest

**Technology Used:**

PLUME STOP Liquid Activated Carbon; HRC HYDROGEN RELEASE COMPOUND




This early test site provides an example of the technology's rapid removal of contaminants from the dissolved phase combined with lines if evidence for post-capture degradation. Mixed chlorinated ethenes and ethanes and their degradation daughter products were reduced to below the 2 - 5 µg/L detection limits over the initial sampling intervals – a reduction of more than 99.9%.

A subsequent increase in solvent degrading bacteria including *Dehalococcoides spp.* – while solvent concentrations in groundwater remained close to or below detection limits – provides an indication of solvent degradation proceeding at the carbon-water interface without impacting the 'open' groundwater. The maintenance of concentrations below detection limits beyond the calculated sorptive capacity of the emplaced carbon under conditions of ongoing contaminant influx suggests the degradation is freeing up sorption sites for further contaminant capture.

## Case Study – Downtown Chicago

### Site Details

**Site Type:** Former industrial manufacturing plant

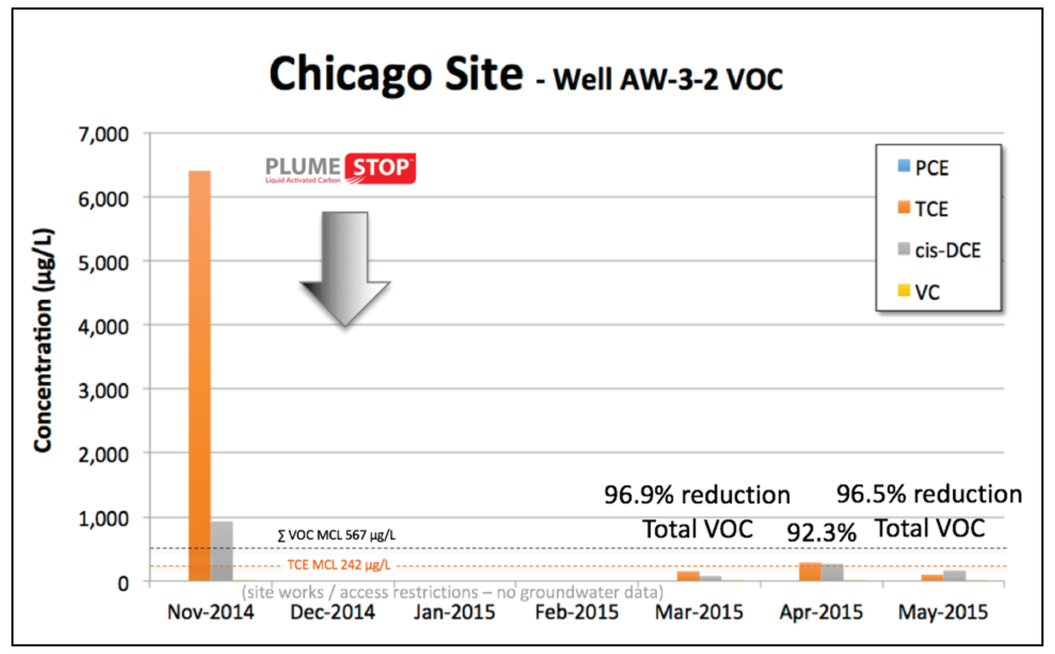
**Contaminant of Concern:** PCE and TCE residues – up to 7,440 µg/L

**Remediation Approach:** Enhanced Biodegradation,

**Soil Type:** Sand formation over clay
– Treatment area 13,500 sq ft
– Treatment Zone 10' - 22' – (3 - 7 mbgl)

**Technology Used:**

PLUME STOP Liquid Activated Carbon; HRC HYDROGEN RELEASE COMPOUND; BDI BIO-DECHLOR INOCULUM




This full-scale commercial project provides an example of bioremediation – supported by PlumeStop – being selected over chemical oxidation in the interests of time. The rapid concentration reduction secured by the PlumeStop and ability to quickly determine performance success unlocked the positive benefits of bioremediation usually prohibited from time-sensitive development-driven projects such as this.

The PlumeStop bio approach presented the further safety advantage of ensuring excavation dewaterings did not contain contaminants or chemical oxidation agent residuals. This reduced health risks in the event of worker contact and secured the possibility to dispose of dewaterings directly to sewer without the requirement of costly pre-treatment.

- ∑VOC targets met – from first sampling round (through all rounds)
- TCE targets met – from second sampling round (and degrading fast)
- Completion report submitted – five months from application (June 2015)
- No further action required

## Case Study – California Central Coast

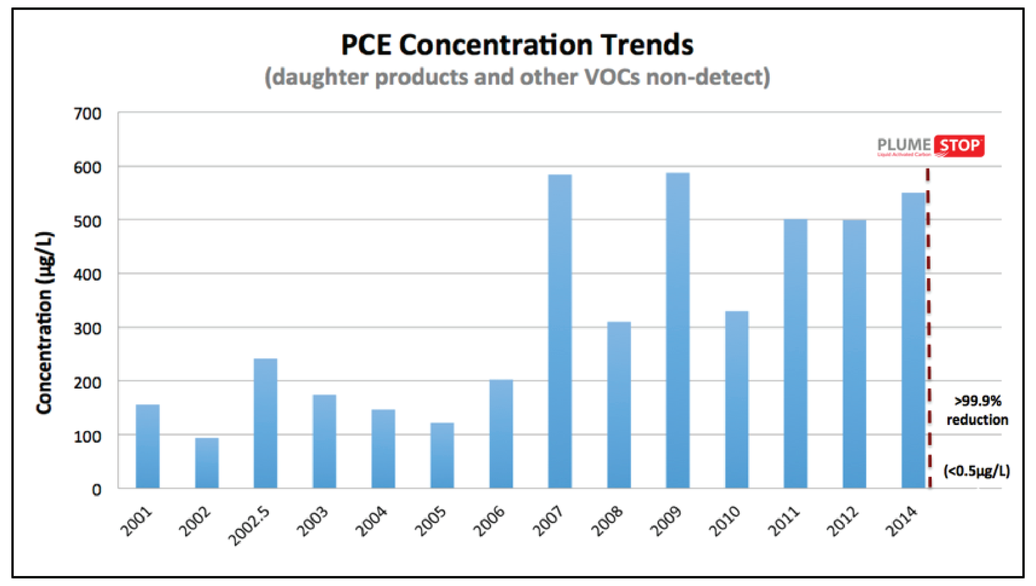
### Site Details

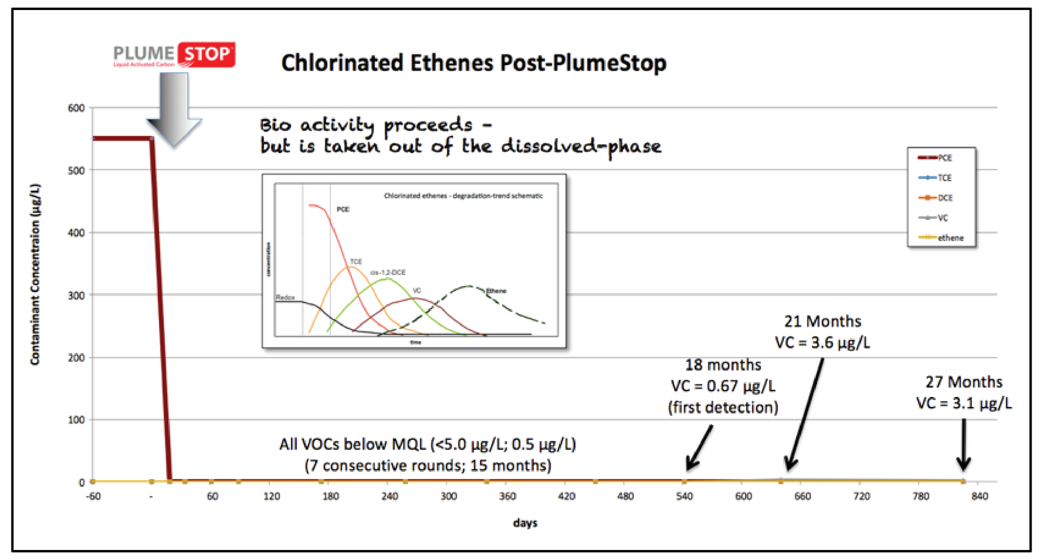
**Setting:** 'Dune Sand' formation, High redox conditions (aerobic)

**Contaminant of Concern:** PCE 550 µg/L

**Soil Type:** Sand, 33 ft/yr groundwater flow

**Technology Used:** PLUME STOP Liquid Activated Carbon




This early test study provides an indication of performance over an extended time line. Post-treatment PlumeStop performance through 27 months to date contrasts sharply with historic contamination data trends dating back more than a decade. PCE contamination was reduced from 550 µg/L to below laboratory detection limits of 5 µg/L from the first sampling event (>99% reduction).

A reduced detection limit of 0.5 µg/L from the two-month point onwards still recorded no VOC contamination (>99.9% reduction) through seven consecutive sampling rounds.

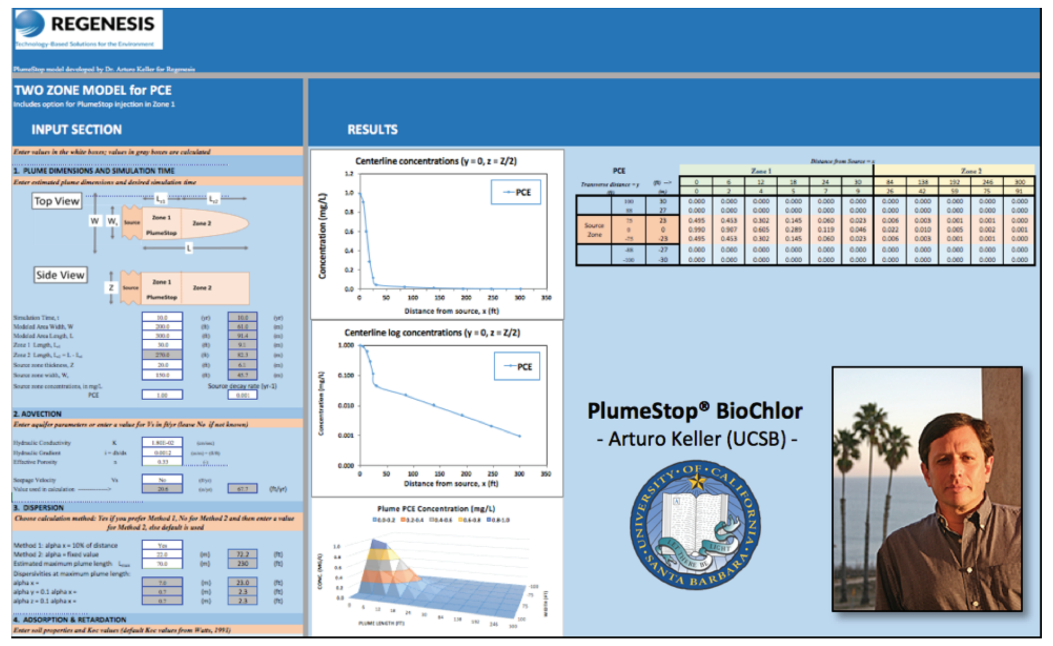
Traces of vinyl chloride were then detected after 18 months at 0.67 µg/L, peaking at 3.6 µg/L and then declining once more. The boundary-detection of this weakly sorbing daughter product with no prior detections of the TCE or DCE intermediates of PCE degradation provides a further line of evidence of PCE degradation proceeding on the PlumeStop post initial capture.

## Passive Engineering of Migrating Plume Dynamics

The ability to flow-emplace a micron coating of activated carbon through the transmissive zones of the subsurface opens up the possibility of controlling and containing contaminant plume movements without the need for active pumping. The contaminants are captured by the carbon particles while the groundwater flows freely. Rather than pumping out contaminated water and passing it through activated carbon *ex situ*, the activated carbon can be emplaced into the contaminant flow channels *in situ* to clean groundwater.

Sorbed contaminants may then be biodegraded on the activated carbon regenerating its sorptive capacity *in situ*. This is supported through periodic application of compatible electron donors or acceptors into the (more focused) treatment zone.

Alternatively, the migration of natural donors or acceptors may be sufficient to secure the necessary bio-attenuation of the contaminants on the carbon, as these are typically not retained and therefore flow through, providing the required growth factors for the bacteria in the PlumeStop barrier.




Contaminant fate and transport assessments for designing plume control and predicting potential emplacement outcomes of PlumeStop applications can now be assisted using a modified US EPA BIOCHLOR model. This is made possible by an additional PlumeStop component integrated into the model by Professor Arturo Keller (University of California, Santa Barbara).

Desirable fate and transport outcomes may be explored through the model through a variety of placement and dose scenarios inputted by the user. These may involve a variety of different placement and capture-zone dimensions for example, as befitting site access or considerations. PlumeStop then enables the modelled outcome to be turned into a reality – the retardation factor is now an engineering variable.