

# Successful Bioremediation of A Source Area within A Comingled Plume

Pawan Sharma  
(CDM, Walnut Creek, California)  
Howard Young  
(CDM, Irvine, California)

## Abstract

The uppermost two aquifers underlying a chlorinated ethene source area were treated with Hydrogen Release Compound® (HRC) injections. After four years, elevated levels of total organic carbon (TOC) and high rates of complete reductive dechlorination continue to be observed at wells within the treatment area. Over this period, tetrachloroethene (PCE) and trichloroethene (TCE) and their degradation product cis-1,2-dichloroethene (cDCE) and vinyl chloride (VC) decreased to below respective cleanup levels. However, the most recent data indicates fluctuations of PCE, TCE, and cDCE concentrations to above cleanup levels. Given the recent fluctuations, it is likely that sorbed fractions of PCE and TCE remain in the source area, continuing to dissolve into the aqueous phase, and the aquifer system has not yet reached equilibrium. Evaluation of source area bioremediation is further complicated by a constant influx of TCE and cDCE from an upgradient, off-site source. A long-term benefit of the source area bioremediation has been an increased rate of natural attenuation of TCE across the downgradient portion of the plume, outside of the influence of the HRC injections.

## Background

The primary release to groundwater was from waste chlorinated solvents stored in a former underground storage tank. Site geology consists of interbedded clay and silty sand with the main water bearing zones occurring in silty sand. The immediate source area was backfilled with gravel to approximately 10 feet below the water table during tank removal activities. Based on favorable results from a natural attenuation study, in situ enhanced anaerobic bioremediation using HRC injections was initiated in 2000 and the groundwater pump and treat system was shut down.

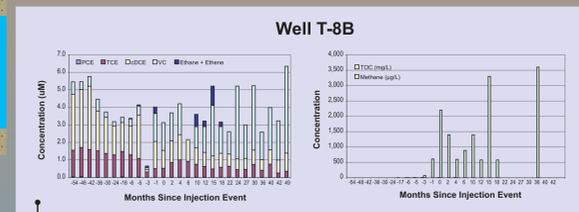
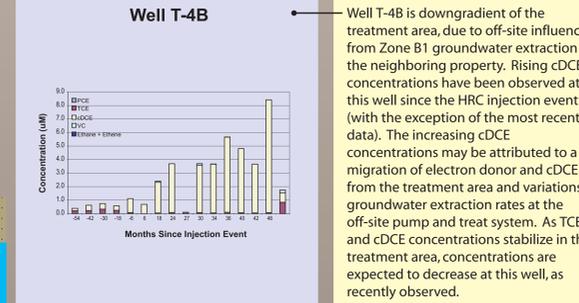
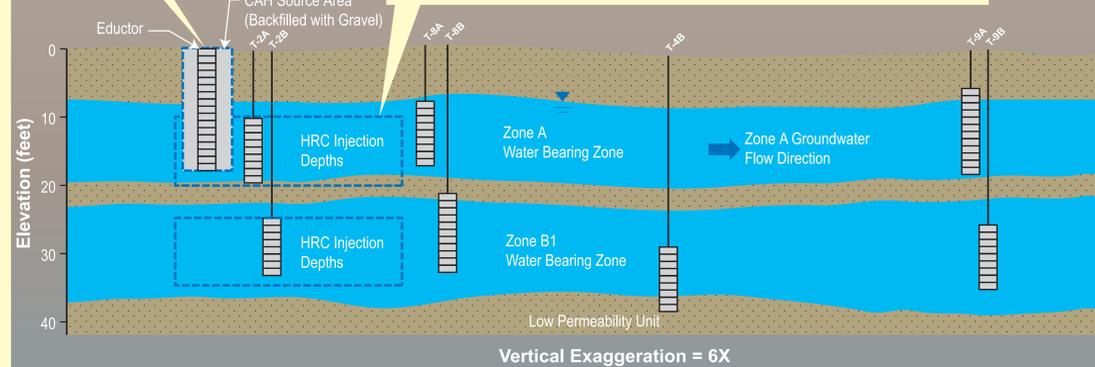
## HRC Injections and Monitoring Results

**Upgradient Zone A Groundwater Chemistry** - TCE and cDCE consistently detected in monitoring wells upgradient to the site.

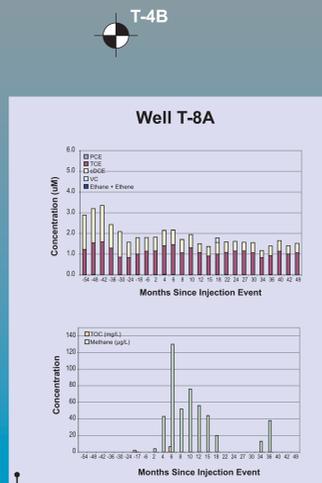
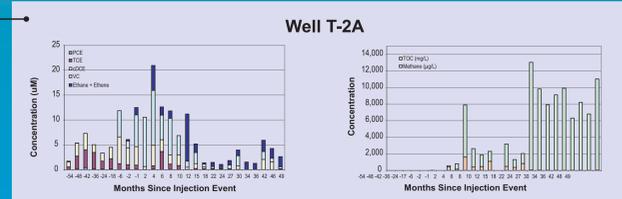
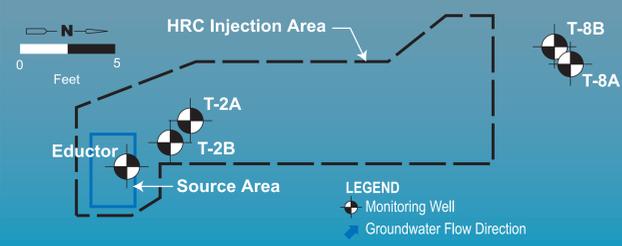
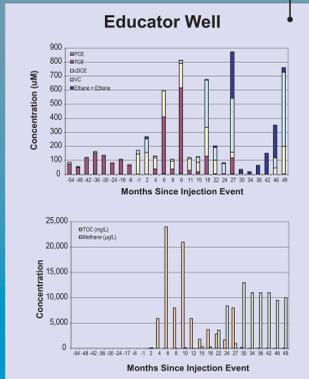
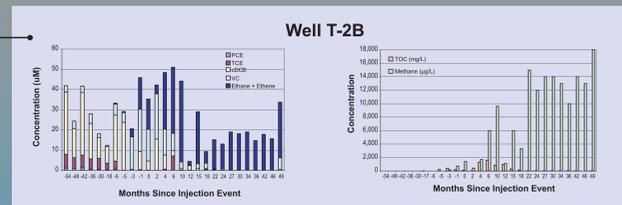
Chloroethenes	
PCE (µg/L)	<1.0 - 2.0
TCE (µg/L)	220 - 510
cDCE (µg/L)	7.1 - 268
VC (µg/L)	<1.0
General Environmental Parameters	
ORP (mV)	151-202
Total Organic Carbon (mg/L)	<5.0
Electron Acceptor Values	
Nitrate and Nitrite (mg/L)	0.84 - 3.0
Sulfate (mg/L)	83 - 190
Metabolic Byproduct Values	
Ferrous Iron (mg/L)	<1.0
Dissolved Manganese (mg/L)	0.012
Sulfide (mg/L)	<2.0
Methane (µg/L)	0.10
Ethane (µg/L)	0.006
Ethene (µg/L)	0.014

Previously, a UST was removed from the source area and soil was excavated to a depth of 18 feet. The excavation was backfilled with gravel and the Eductor well was installed within the gravel fill.

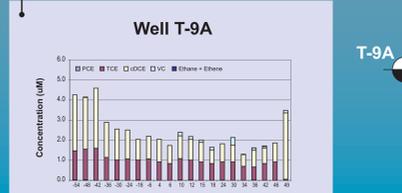
Injection Event	Number of Injection Points	Injection Depth	Injection Amount	Total Mass of HRC Injected
October 2000	29	25 to 35 feet	6 to 10 lbs/ft	2,380 lbs
June 2001	30	10 to 20 feet	8 to 10 lbs/ft	3,300 lbs
	8	25 to 35 feet	8 to 10 lbs/ft	3,300 lbs



TOC levels decreased to near background levels approximately 2 to 3 years after the HRC injection event, indicating HRC has been mostly consumed. However, with these lower TOC levels, elevated concentrations of methane and other metabolic byproducts continue to indicate methanogenic conditions persist in the treatment area and high rates of complete reductive dechlorination continue to occur.



The most recent data indicates a dramatic decrease of TCE concurrent with an increase in cDCE at this downgradient Zone A well. This apparent biodegradation in TCE may be due to co-metabolic oxidation with methane. Further monitoring and trend evaluation is required. As sulfate-reducing conditions exist at this well, the methane is believed to be a result of methane migrating from the treatment area.



## Results and Findings

Based on elevated levels of TOC, methane, and ethene in source area wells, methanogenic conditions favorable for complete reductive dechlorination continue four years after the HRC injections.

In Zone A and Zone B1 groundwater, within the treatment area, PCE, TCE, cDCE, and VC were reduced to below site cleanup goals 2 to 3 years after HRC injections.

Recent fluctuations in both Zone A and Zone B1 PCE, TCE, cDCE, and VC concentrations indicate the presence of remaining source area mass, likely sorbed phase PCE and TCE dissolving into the aqueous phase. However, migration of TCE and cDCE from an upgradient off-site source may also be contributing to the recent detections in Zone A.

Source area bioremediation provided enhanced dechlorination of the sorbed phase PCE and TCE by degrading contaminants from the aqueous phase and increasing their driving force for mass transfer; increasing solubility of cDCE and VC greatly increases the maximum aqueous contaminant loading; and generating of metabolic acids from HRC that accelerated dissolution/desorption abiotically (i.e., increasing the solubility limit of PCE and TCE).

Metabolic acid formation affected pH and microbial activity at the Eductor. Addition of dilute sodium hydroxide at Eductor after injections was required to keep pH neutral for optimal microbial activity. The low buffering capacity of the gravel fill around the Eductor contributed to this condition.

A recent increase in the TCE attenuation rate at T-9A may be attributed to co-metabolic anaerobic oxidation with the methane. Methane has recently been detected at this well. As the well was not directly affected by HRC, the source of the methane appears to be migration from the treatment area.