

Field Studies for Combined Biological and Chemical Reductive Dechlorination for Treatment of Chlorinated DNAPLs

*John S. Haselow
Redox Tech, LLC
Cary North Carolina*

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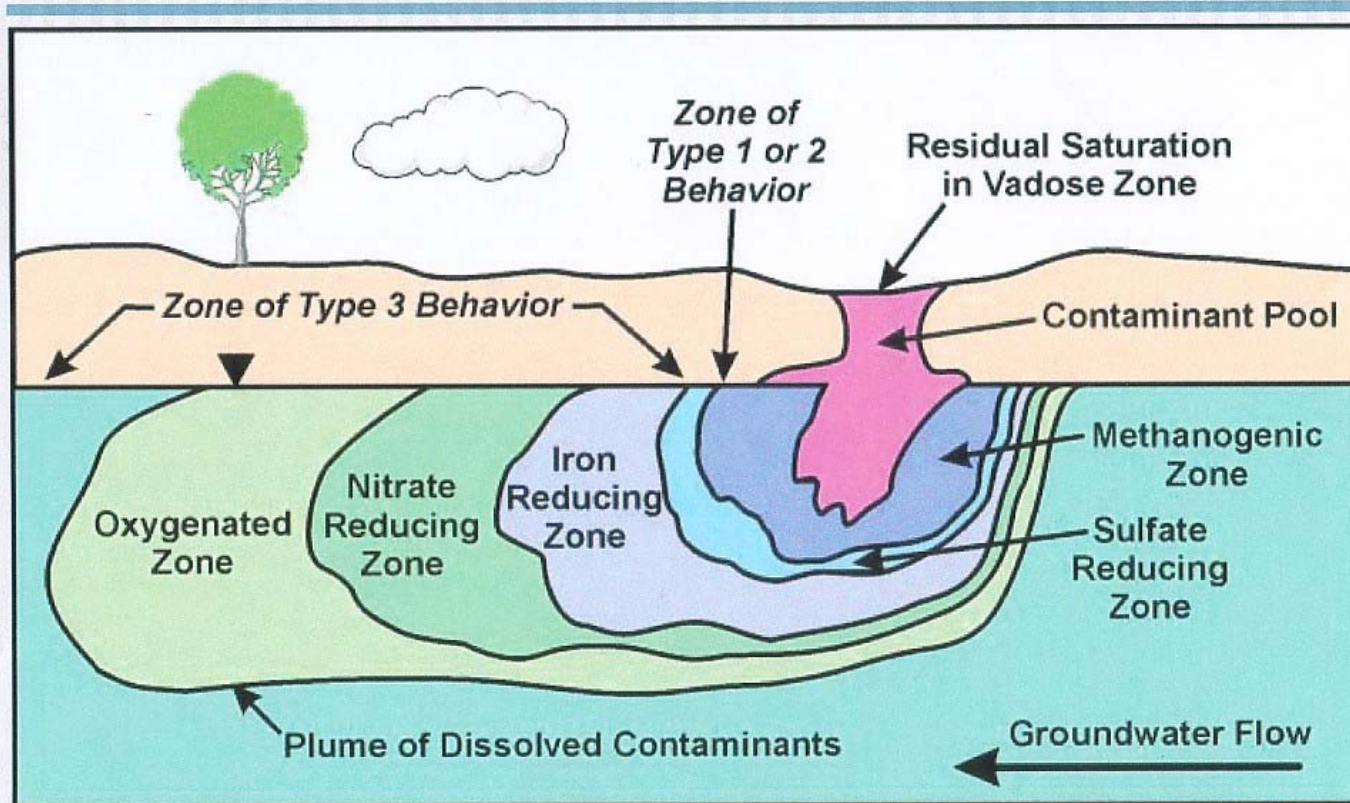
- Founded in 1995
- Provide turn-key *in situ* treatment with biological and chemical manipulation, both reduction and oxidation
- Hydraulic fracturing with Geoprobe
- Soil Blending with specialized equipment
- Offices in GA, IL, NC, RI and IL

REMEDIATION

- Chemical Oxidation
- Chemical Reduction
- Aerobic Bioremediation
- Anaerobic Bioremediation
- Metals Stabilization
- Thermal via Steam Injection

Anaerobic Dechlorination: Basics

Electron Acceptor Zones in the Subsurface



Source: IGWMC, 1996

RITS Winter 2001

11

Reductive Dechlorination Products

- Sodium lactate
- Molasses
- Polylactates
- Cheese whey
- Soybean Oil
- Dairy wastewater
- Off-specification beer
- Zero Valent Iron
- Sodium Dithionite

Anaerobic Biochem (ABC)®

- Granted variance in the State of Florida
- Been applied in 13 States on over fifty sites
- US Patents 6,001,252 & 6,472,198
- License agreement with Adventus for addition of zero valent iron
- Blended and distributed from Cary NC
- Trademark recently approved

Anaerobic Biochem®

Varying Amounts of

- Inexpensive carbon source
- Ethyl Lactate
- Phosphate pH buffer
- Zero Valent Iron
- Vitamin B12

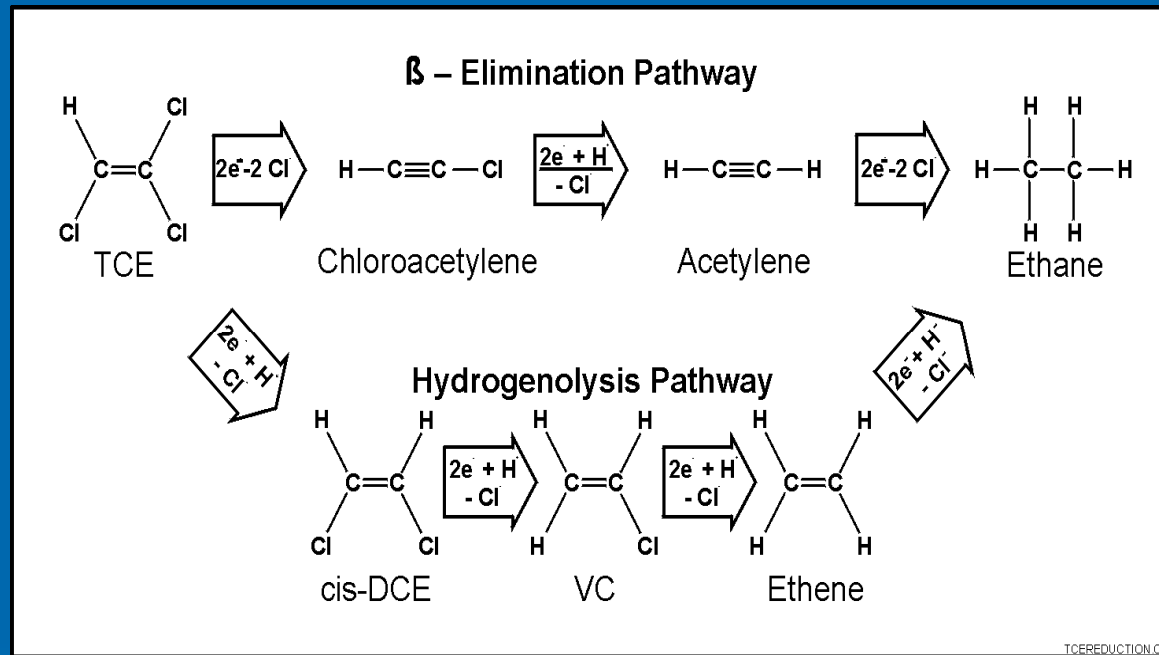
Anaerobic Biochem®

- Ethyl lactate converts to ethanol and lactic acid through hydrolysis.
- Provides co-solvent effect to dissolve non-aqueous phase liquids (Rao *et al*)
- Documented field studies on ethyl lactate for DNAPL recovery (Annable *et al*)
- Reductive reactions are facilitated in aqueous phase

Anaerobic Biochem®

- Phosphate pH buffer provides biological micronutrient and stabilizes the pH around 8 s.u.
- Zero Valent Iron – added for chemical reduction and provides iron catalyst
- Vitamin B12 crucial vitamin needed for cell growth

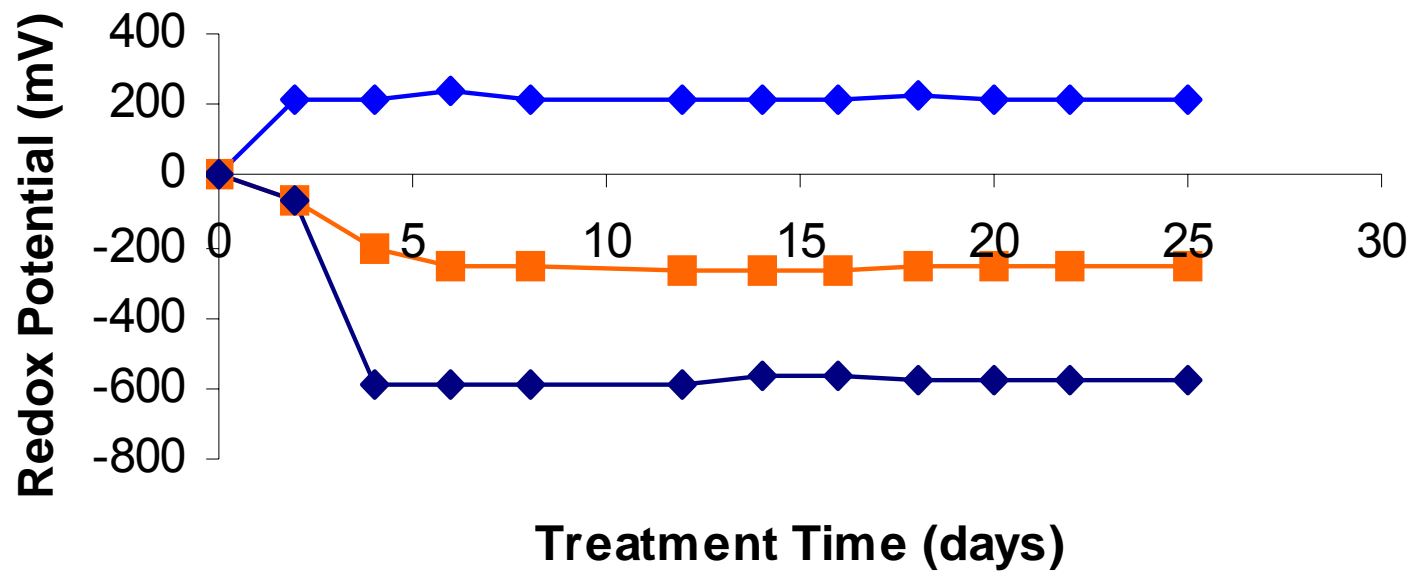
ZVI REACTION



- β -elimination pathway minimizes daughter products
- very low concentration of chlorinated intermediates
- intermediates degrade
- Surface reaction at ZVI

COMBINED BIO and CHEMICAL REDUCTION

Redox Potential Comparison



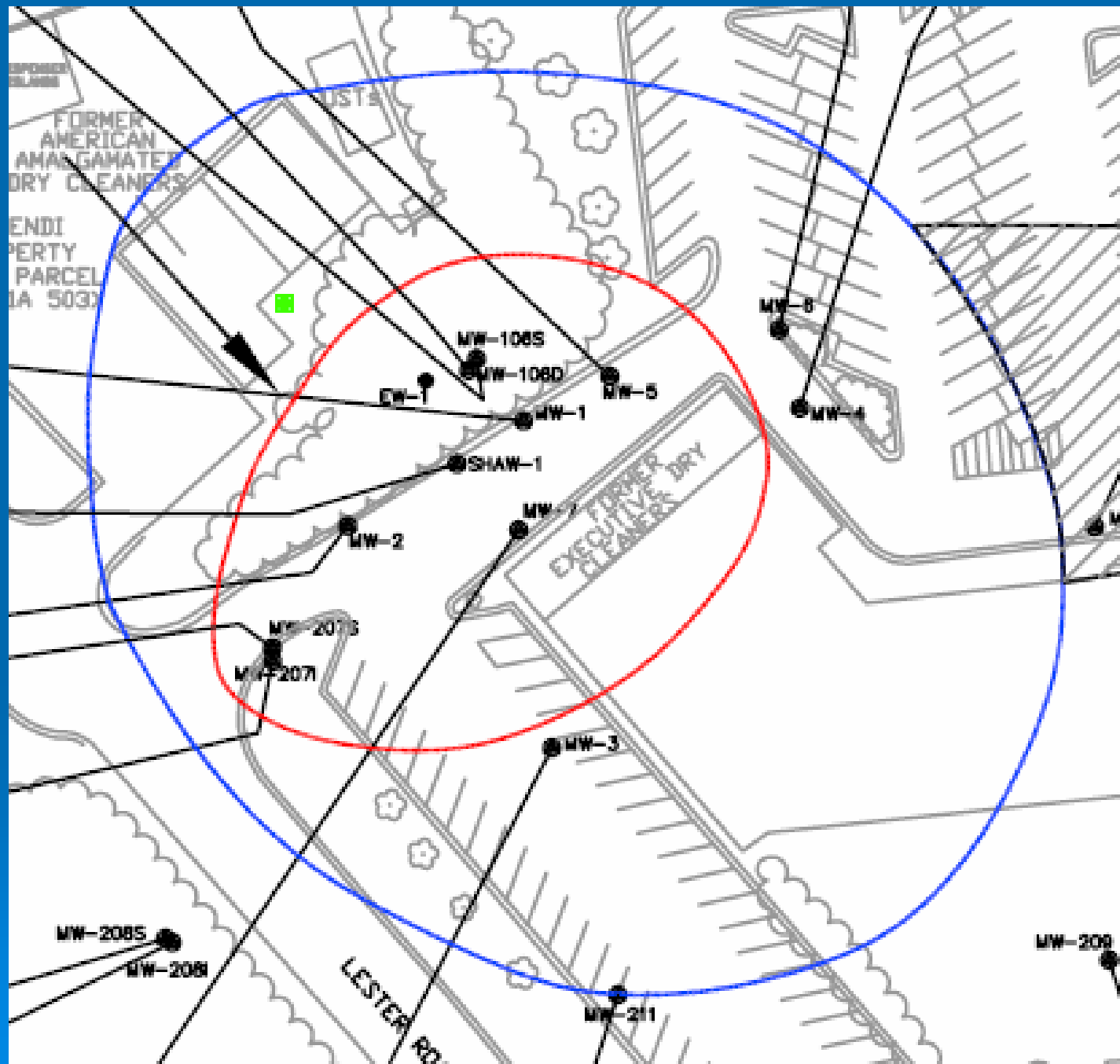
—◆— Control

—■— ABC®

—◆— ABC+®

Case Study #1

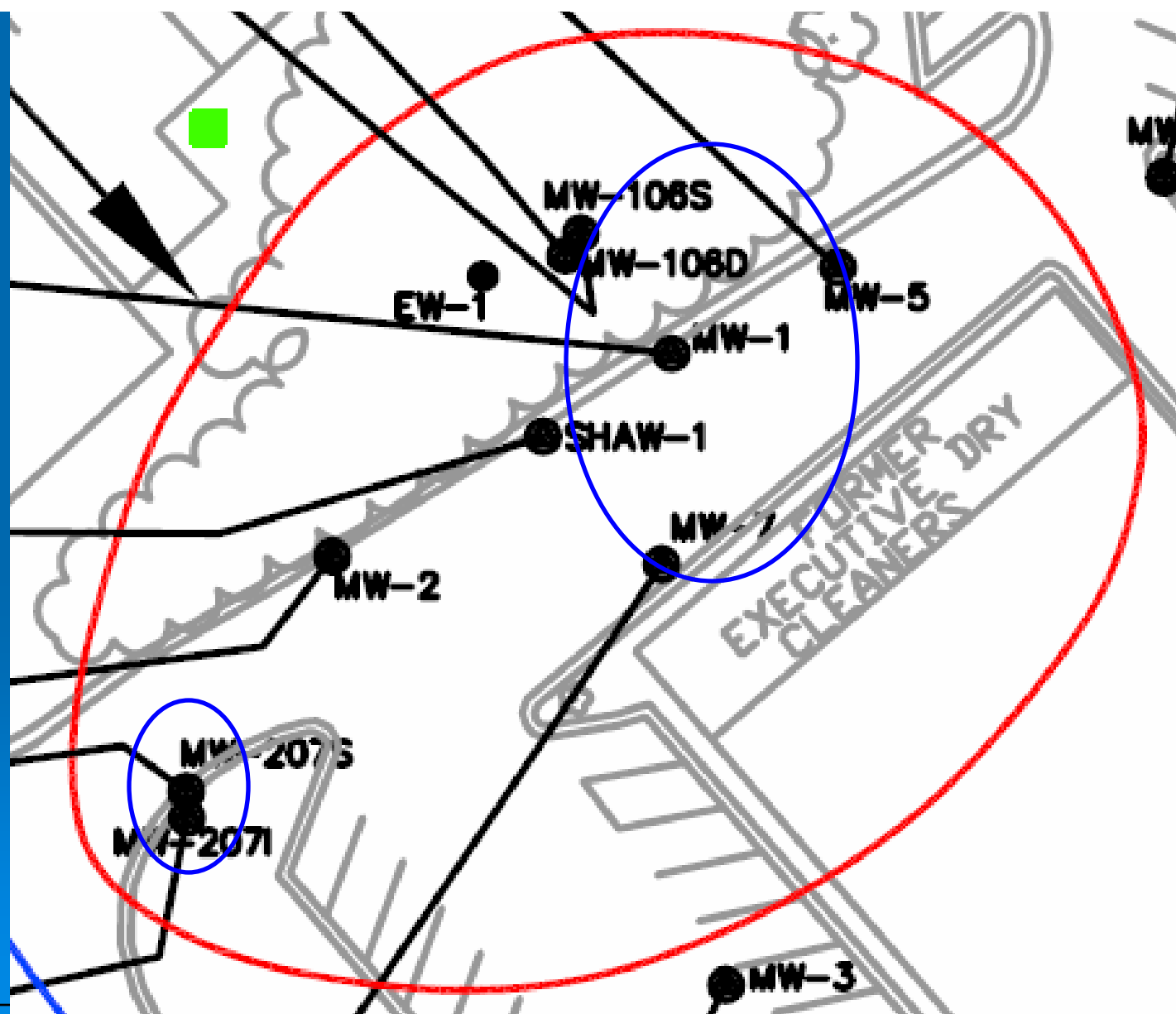
- Piedmont Physiographic Province in Northern Georgia (saprolite)
- Release of PCE from a former drycleaner
- Treatment interval from approximately 20 to 40 below land surface
- Treatment Area ~66,000 square feet



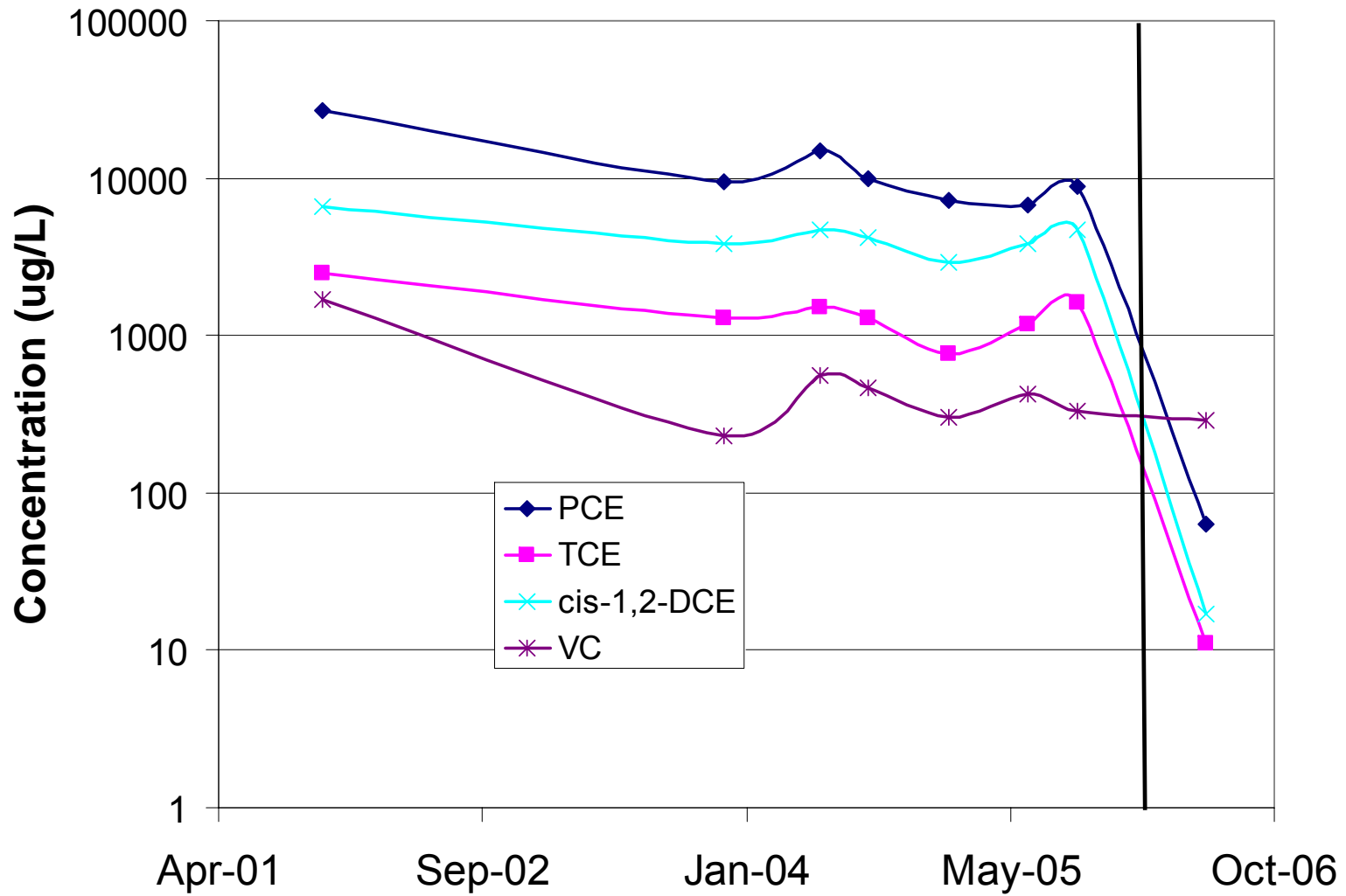
ABC Injections

- 1st injection event – December 2004 – 100 injection points, with 450 pounds ABC per point, at 15 weight percent solution
- 2nd injection event – August 2005 – 55 injection points with 250 pounds ABC per point at 15 weight percent solution

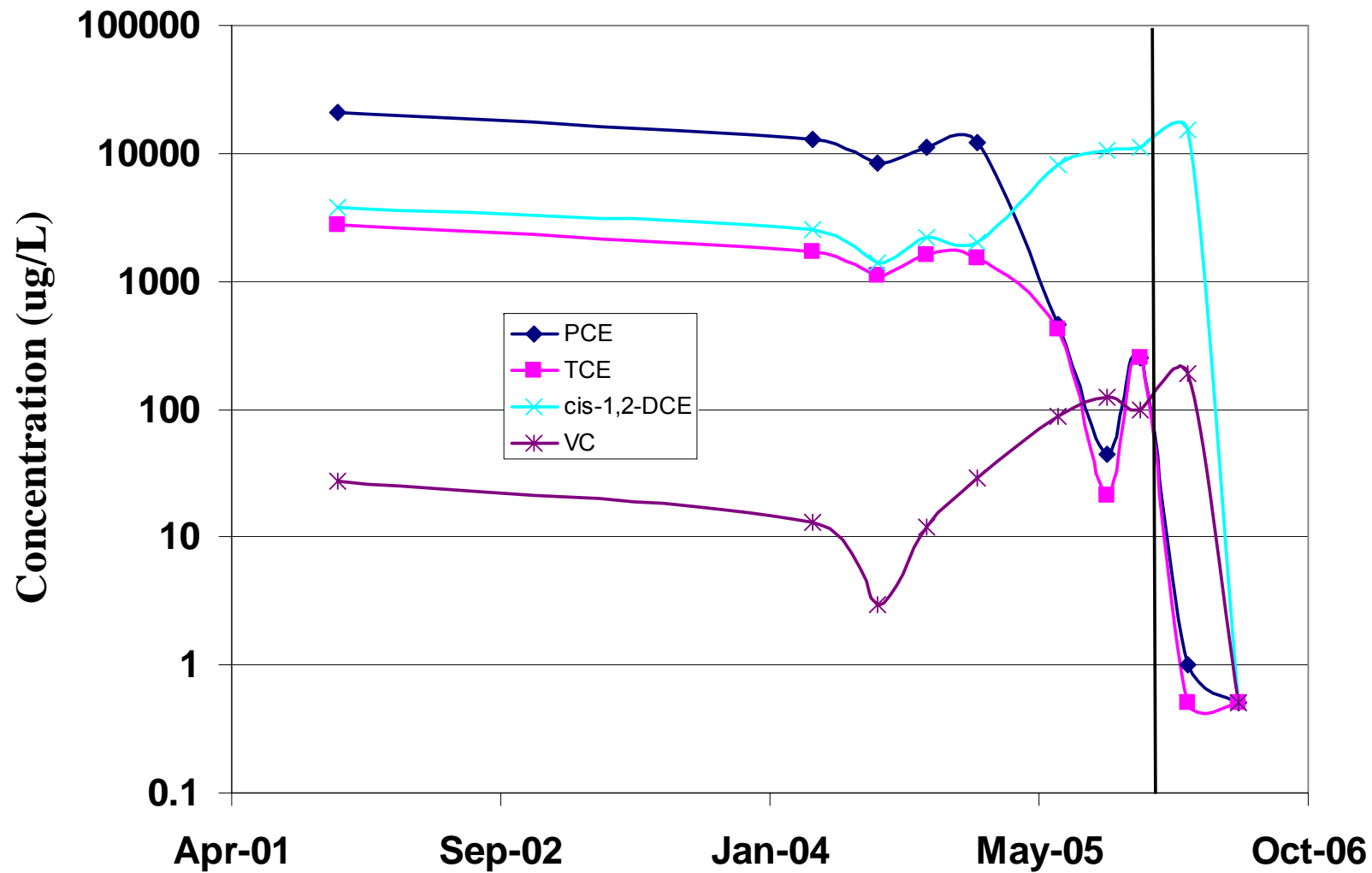
Plume after Two Injections



Time-Trend Analysis: MW-1



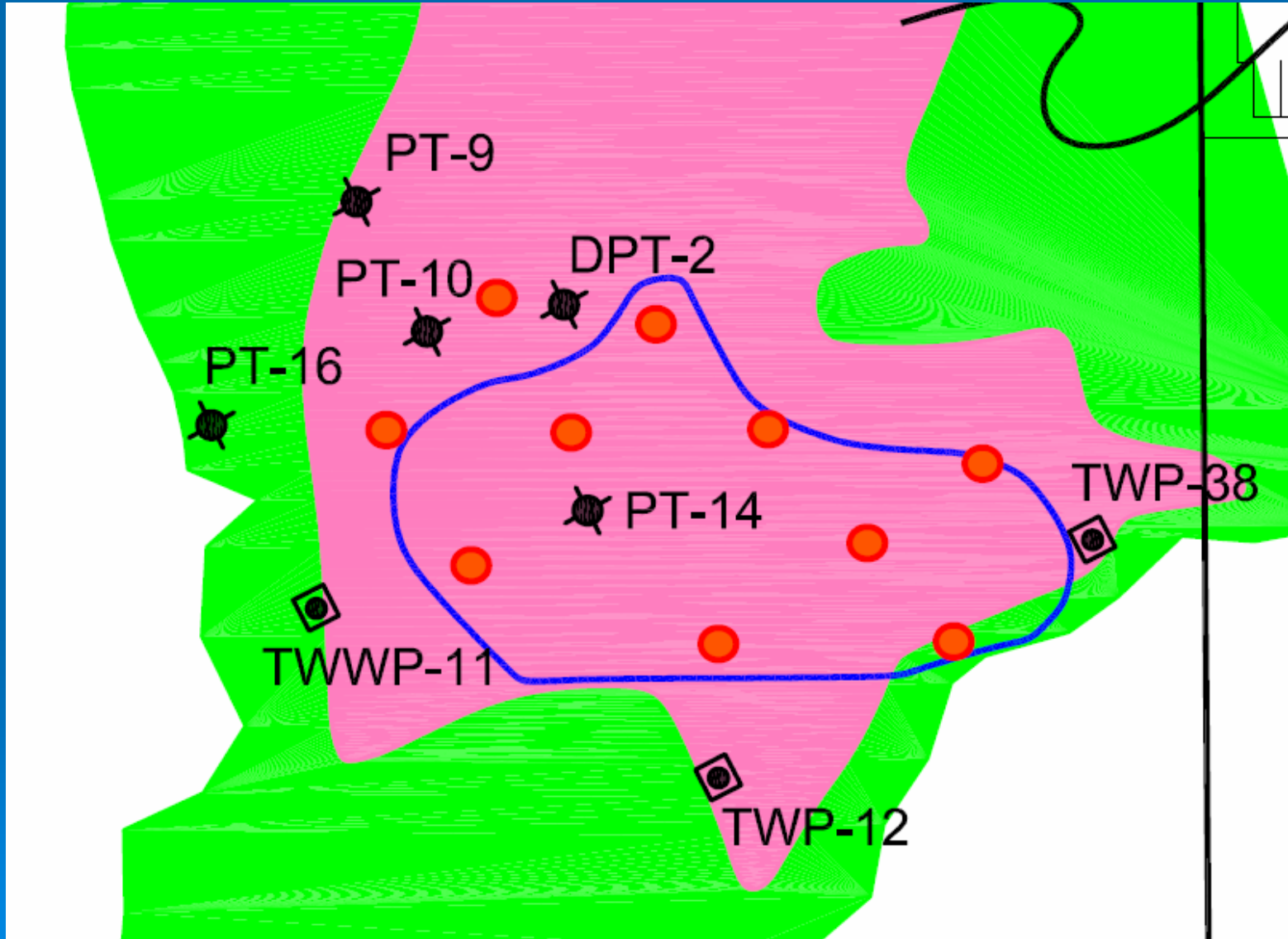
Time Trend Analysis: MW-7



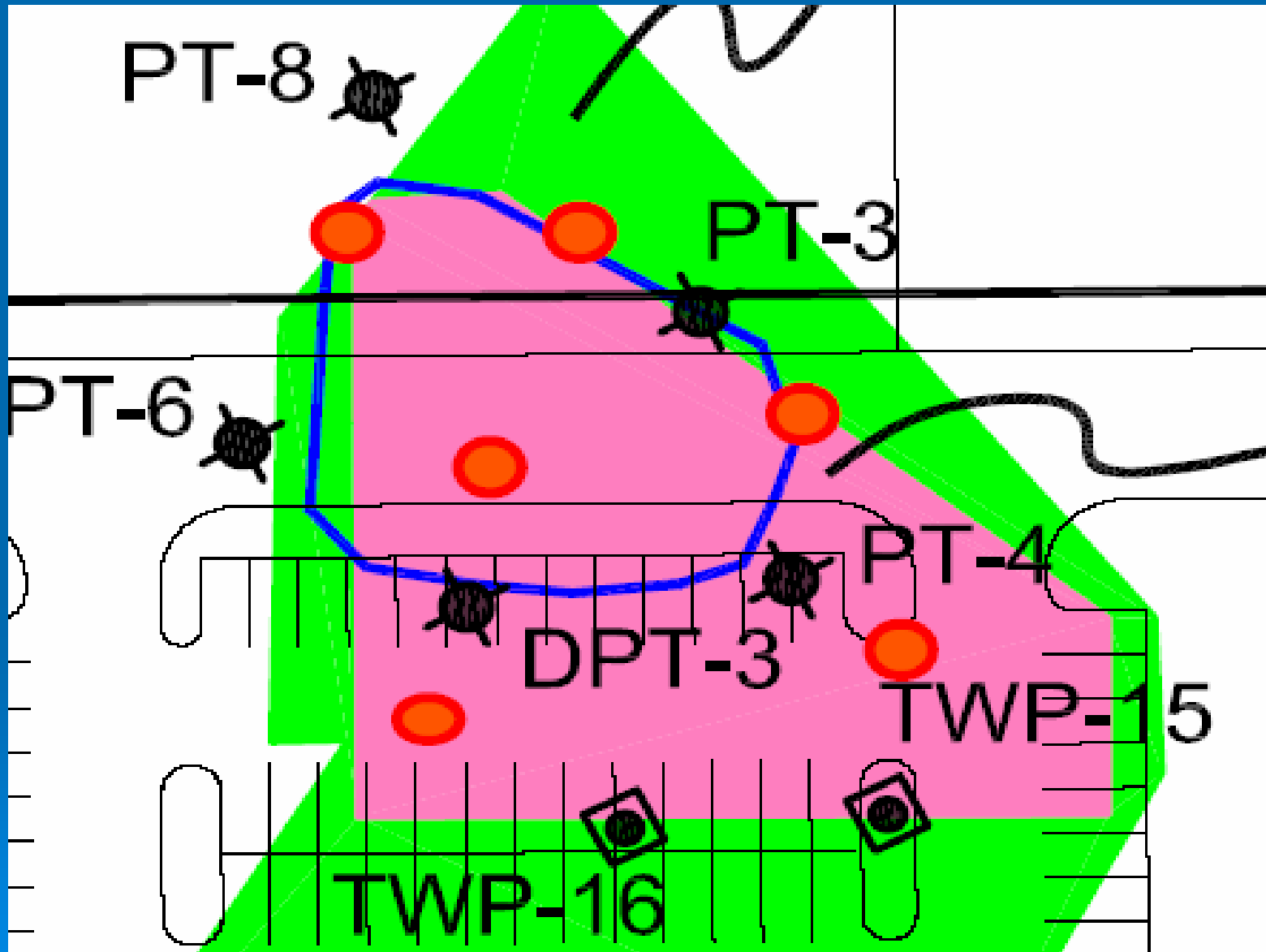
Case Study #2

- Atlantic Coastal Plain Sediments
- Interbedded silt and clay
- Target interval 15' to 25' bls
- Mixture of PCE plus daughters, PCA plus daughters, Freon, chloroform, etc.
- Total VOCs from 10 to 500 ppm in GW
- Goal is removal of DNAPL-like concentrations
- First injection – 32,000 pounds into 16 geoprobe points in April 2006

Area #1



Area #3



Area 1 Data

PT-10			
	08/05	03/06	06/06
Chloroform	16,000	26,000	970
Carbon Tetrachloride	4,600	11,000	67
Freon TF	160,000	170,000	9,900
Methylene Chloride	1	570	79
Carbon Disulfide	1	2,200	1
1,1,2,2- Tetrachloroethane	1	240	1
TOTAL	180,603	210,010	11,018

Area 1 Data

PT-14			
	08/16/05	03/24/06	06/30/06
Methylene Chloride	4,200	1	70
Chloroform	88,000	5,500	450
Carbon Tetrachloride	13,000	2,300	1
Freon TF	120,000	13,000	1,900
TOTAL	225,200	20,801	2,421

Area 3 Data

PT-4			
	08/17/05	03/21/06	06/28/06
Methylene Chloride	3,500	630	140
Trichlorofluoromethane	16,000	1,400	410
trans-1,2-Dichloroethene	2,900	870	270
cis-1,2-Dichloroethene	9,000	1,600	560
Chloroform	4,700	1,100	270
1,2-Dichloroethane	15,000	2,000	610
Trichloroethene	2,900	1,800	10,000
1,1,2,2-Tetrachloroethane	260,000	43,000	920
Dichlorodifluoromethane	2,300	1	1

Conclusion

- ABC plus ZVI is an effective amendment for treating DNAPL like concentrations
- Minimizes production of daughter products
- Cost-effective delivery is achievable through hydraulic fracturing
- www.redox-tech.com