# Remedial Action Using Fenton's Chemistry under a State Dry Cleaning Program

Geoffrey D. Schaefer[1], Michael O. Jaynes[2], and Jennifer A. Farrell[3]

Abstract: Oxy-Cat™, a Fenton's based *in-situ* oxidation process, was injected during a Pilot Test into the subsurface at an active dry cleaning site in September, October, and November of 1999 under the Florida Department of Environmental Protection (FDEP) Dry Cleaning Solvent Cleanup Program (DCSP). The site, located in Jacksonville, Duval County, Florida, has three distinct aquifer zones, all of which are impacted by tetrachloroethene (PCE) and its degradation products at levels well above regulatory cleanup criteria. Tetrachloroethene is used in the dry cleaning industry as a degreaser and waterless cleanser for garments. Its use has resulted in its accidental release into groundwater systems by improper disposal practices. The FDEP Dry Cleaning Solvent Cleanup Program provides a fund administered by the Department for the assessment and cleanup of dry cleaning sites. The source for the cleanup fund is a tax on dry cleaning solvents, both PCE and petroleum-based solvents.

Because of the expense and long-term operation and maintenance associated with *ex situ* groundwater treatment systems, *in situ* remedies were explored to remediate the greater than 16,000 square foot contaminant plume. Fenton's chemistry was selected because it is a low-cost, passive, effective technology for optimizing degradation rates of chlorinated hydrocarbons dissolved in groundwater.

The results of a pilot test, conducted between September 1999 and December 1999, were mixed with groundwater concentrations decreasing in some areas and increasing in others. The majority of the saturated source zone mass is located between 35 and 45 feet bls. The dissolved concentrations in this interval fluctuated during the pilot test. Indicating a large source mass and conflicting manifestations of desorption, solubilization and destruction.

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[1]Geoffrey Schaefer, Staff Engineer, Harding ESE, Inc., 2533 Greer Road, Tallahassee, Florida, 32308, USA, Ph 850.656.1293, Fx 850.656.3386, gdschaefer@mactec.com

[2]Michael Jaynes, P.E., Senior Engineer, Harding ESE, Inc., 2533 Greer Road, Tallahassee, Florida, 32308, USA, Ph 850.656.1293, Fx 850.656.3386, mojaynes@mactec.com

[3]Jennifer Farrell, Contract Manager, Florida Department of Environmental Protection, Hazardous Waste Site Cleanup Section, 2600 Blair Stone Road, Tallahassee, Florida, 32399-2400, USA, Ph 850.488.0190, Fx 850.922.4368, jennifer.a.farrell@dep.state.fl.us

The dry cleaner in this study has been operating at its present location in south central Jacksonville, Florida since 1971. There are no other active drycleaning establishments in the site vicinity, although a drycleaning business was formerly located east of the subject facility. Two aquifer systems of interest underlie the site area; the Floridan aquifer system, which is the primary source of potable water in Duval County; and the surficial aquifer system that includes a shallow-rock aquifer that is an important secondary source of potable groundwater in some areas. Groundwater is encountered in the surficial aquifer, consisting of sand and clayey sand, from approximately 12 feet bls in the higher ground elevations to approximately 3 feet bls in the lower elevations. The groundwater flow direction in the surficial aquifer zone is to the west-southwest. The hydraulic conductivity was estimated for wells screened in the shallow (20'- 22' bls), intermediate (30'- 32' bls), and deep (40'- 42' bls) zones of the aquifer based on results calculated from rising head slug tests. The estimated hydraulic conductivity (K) for wells in the shallow zone was estimated to be 12.29 feet/day. In the intermediate zone wells, the average K was estimated to be 15.10 feet/day, and in the deep zone wells K was estimated to be 11.52 feet/day.

Oxy-Cat™ is a proprietary *in-situ* chemical oxidation technique based on Fenton's chemistry, which breaks down soil and groundwater contaminates into harmless byproducts (carbon dioxide, water, and chloride). The process uses an injection of a ferrous iron ($Fe^{2+}$) catalyst followed by 25-50% hydrogen peroxide ($H_2O_2$). The iron catalyst is used as an oxygen transfer element causing the hydrogen peroxide to break down into hydroxyl radicals ($OH^*$), one of the most powerful oxidizing agents.

The general mechanism of the Fenton reaction follows this pathway:

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^- + OH^*$$

The iron acts as a catalyst in the system because it can be regenerated by:

$$Fe^{3+} + H_2O_2 \rightarrow Fe^{2+} + HO_2/O_2^- + H^+$$
$$Fe^{3+} + HO_2/O_2 \rightarrow Fe^{2+} + O_2 + H^+$$

In addition, the common reaction of hydroxyl radicals with organic compounds is:

$$C_6H_6 + 30\ OH^* \rightarrow 6CO_2 + 18H_2O$$

The chemical oxidation procedure has several requirements. The pH of the groundwater must be in the optimum range of 3-6, which for most groundwater is achieved easily by the addition of the catalyst solution.

Site assessment at the Swift Cleaners indicated the presence of a soil source area with levels of tetrachloroethene (PCE) as high as 21,000 µg/kg. The groundwater PCE plume originates at the area of soil contamination and migrates vertically to a depth less than 60 feet bls and laterally westward approximately 340 feet. Concentrations of PCE in the groundwater were found

as high as 4,500 µg/L in the intermediate zone and 10,000 µg/L in the deep zone.

Data indicate that *in-situ* chemical oxidation with hydrogen peroxide is capable of remediating both dissolved-phase and adsorbed-phase PCE at this site. Full-scale remediation efforts are scheduled to begin in April 2001. Results of the full-scale remediation and how they compare to the pilot test results will be presented.

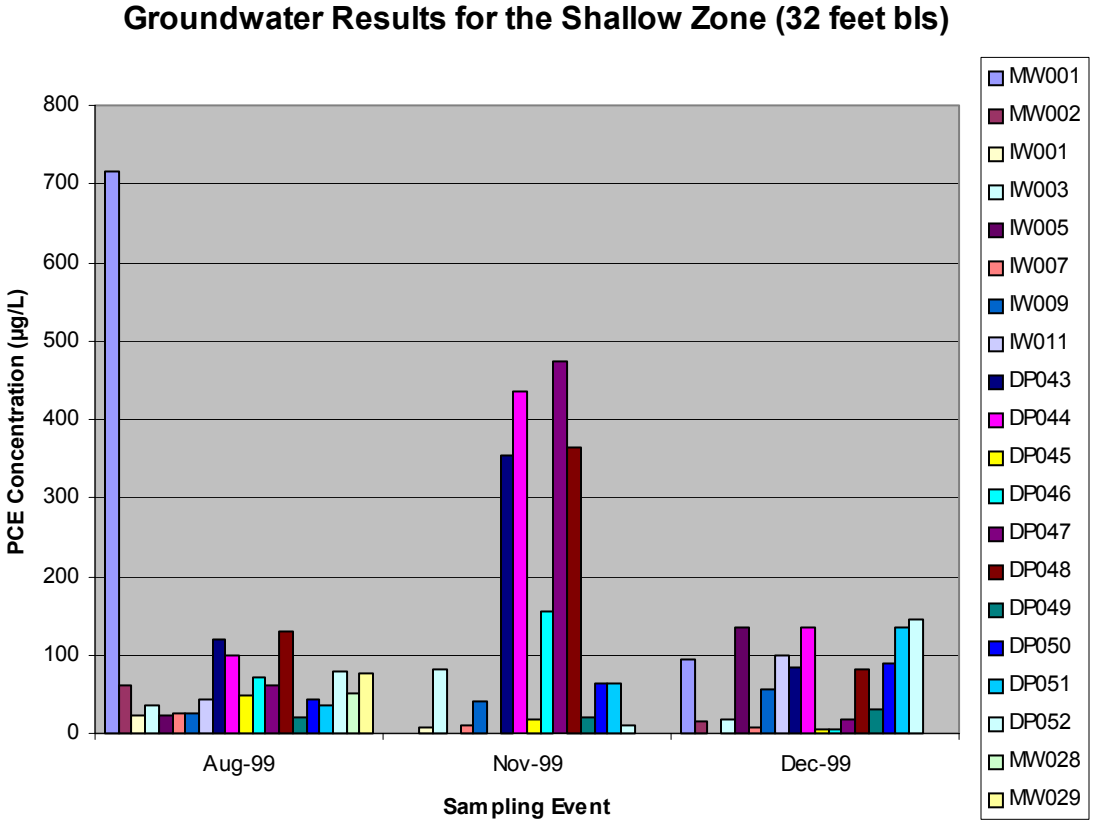


**Figure 1:** Results from the Pilot Test indicate the initial release of PCE from an adsorbed phase followed by chemical destruction via Fenton's reaction. Results shown are from the shallow zone and are typical for the site.

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