MTBE Case Study
***In Situ* Bioremediation at Gas Station, Cheshire, Connecticut**

Site Name: Gas Station (actual site name confidential)

Site Location: Cheshire, CT

Contaminants: MTBE, BTEX, TPH

Media: Groundwater

Technology: *In Situ* Bioremediation

Technology Scale: Full

Type of Cleanup: RCRA UST (Connecticut LUST Program)

Period of Operation: October 1997 to March 1999

Project Contact:
David Lis, IEP
Apex Environmental
58H Connecticut Avenue
South Windsor, CT 06074
Telephone: (860) 282-1700

State Contact:
Alan Davis
Connecticut Dept. of Environmental Protection
79 Elm Street
Hartford, CT 06106-5127
Telephone: (860) 424-3342

Vendor:
Brian L. Clark, P.E.
Executive Vice President
Enzyme Technologies, Inc.
5228 NE 158th Avenue
Portland, OR 97230
Telephone: (503) 254-4331 x11
Fax: (503) 254-1722
E-mail: brianc@enzymetech.com

Site History [1, 2, 3]:

Releases from underground storage tanks (USTs) at an active gasoline service station located in western Connecticut resulted in contamination of groundwater at the site with MTBE and BTEX. Concentrations of MTBE and BTEX measured in groundwater at the site were 6,000 ug/L and 14,000 ug/L, respectively. The vendor estimated that 1,000 cubic yards of soil and groundwater at the site were contaminated as a result of the release. Figure 1 shows a site plan, including locations of USTs.

In the early 1990s, the USTs were removed and decommissioned. A groundwater extraction and treatment system and an air sparging/soil vapor extraction (SVE) system were installed to treat soil and groundwater at the site. In 1997, the groundwater treatment and air sparging/SVE systems were replaced with *in situ* bioremediation, which is the subject of this report.

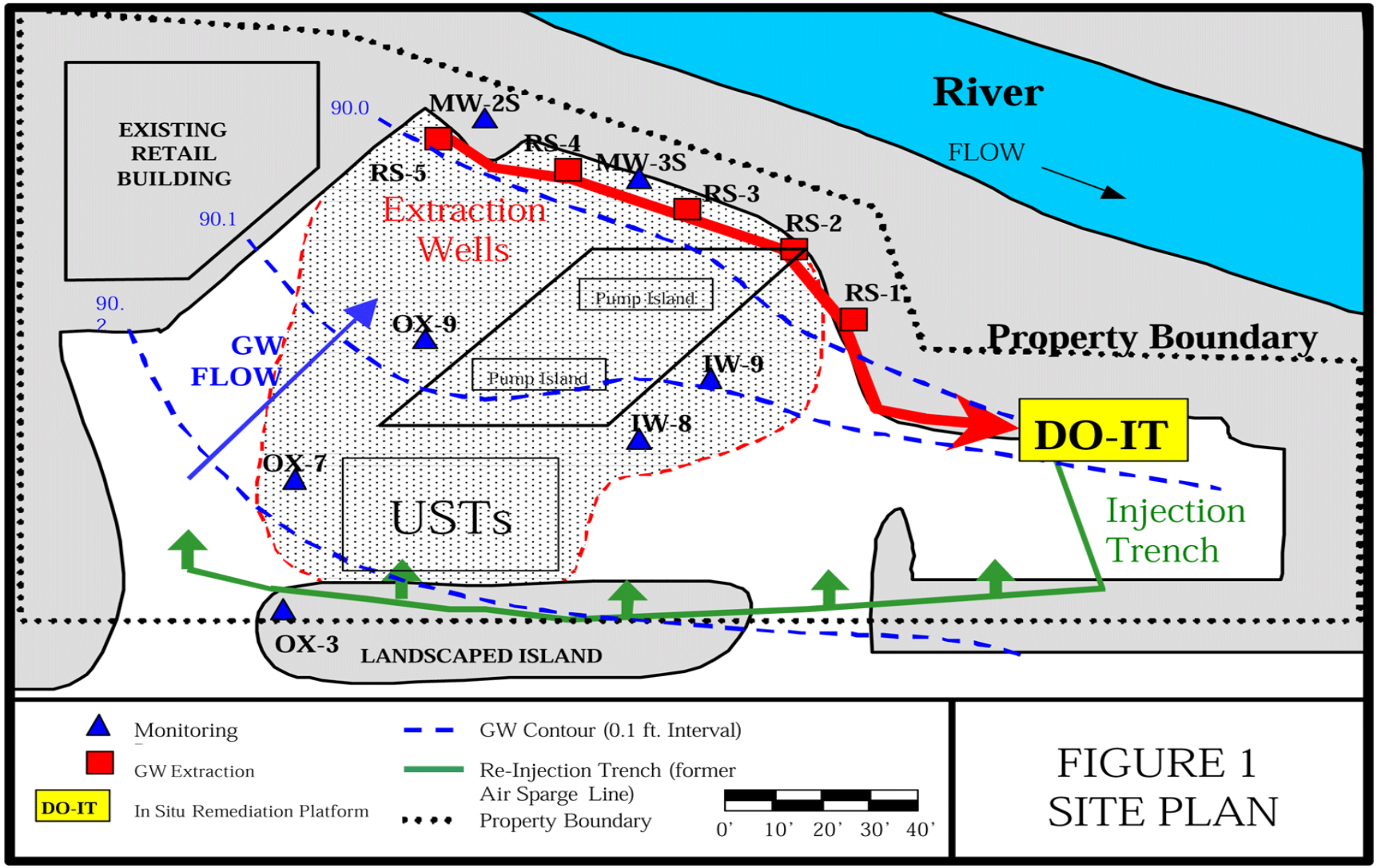
The soil at the site is fine- to medium-grained sand with traces of silt and gravel. Boring logs also suggest the presence of gravel channels within the sand matrix. Groundwater is found at less than 10 feet below ground surface (bgs).

Technology Description [1, 2, 3, 4]:

Beginning in October 1997, *in situ* bioremediation using the Enzyme-Catalyzed In Situ Dissolved Oxygen Treatment (DO-IT) process was used to treat groundwater at the site. This process uses a combination of proprietary multi-enzyme complexes and a consortium of total petroleum hydrocarbon (TPH) degrading bacteria, with supplemental oxygen, to biodegrade MTBE, BTEX, and TPH contaminants. According to the vendor, the enzymes are complex proteins that are extracted from living TPH-degrading bacterial cultures. The enzymes catalyze the conversion of aromatic and aliphatic hydrocarbons to fatty acid, and the bacterial consortium then provides mineralization of the remaining hydrocarbons and fatty acid complexes to carbon dioxide and water. The process generates a concentration of dissolved oxygen in water of approximately 40 mg/L.

The DO-IT process was applied at this site by retrofitting an existing horizontal air sparging trench and vertical vapor extraction wells as injection points for the oxygenated water, nutrients, and enzyme/bacterial consortium mixture. Amendments were injected into the horizontal trench, and manually into the vertical wells. Groundwater was extracted from an existing group of wells located down-gradient from the injection points, which created a closed-loop treatment system and cycled groundwater within the contaminated area. This layout provided for both treatment and hydraulic control of the contaminated groundwater. Hydraulic control was identified by the vendor as important for this site, which was located less than 100 ft from a river. Oxygen-laden water was injected on a daily basis into the subsurface at the site. Nutrients, including nitrogen, phosphorus, and potassium, were dissolved in the injection water, and applied “as necessary” during the remediation. Information was not available about the amount of amendments added, or the dates for adding amendments. Active recirculation and amendment of contaminated groundwater was performed for 18 months.

Figure 1. Site Plan - Connecticut Gas Station [3]



Technology Performance [1, 2, 3, 4]:

The cleanup criteria specified for groundwater at this site were MTBE - 70 ug/L, benzene - 1 ug/L, and TPH - 500 ug/L.

Monitoring wells within the contaminated area, shown on Figure 1, were used to assess performance of in situ bioremediation at this site. Data are available for both the first 34 days of operation and the first 12 months of operation, and discussed below.

Figures 2 and 3 shows the concentrations of MTBE and BTEX, respectively, in selected wells during the first 34 days of treatment using *in situ* bioremediation. The wells shown on Figure 2 are IW-9, located near the center of the plume, MW-3S, located at the down-gradient part of the plume, and IW-8, located near the up-gradient part of the plume. As shown on Figure 2, the concentration of MTBE in well IW-9 was reduced from approximately 6,000 ug/L to 1,600 ug/L (a 73% reduction) and in well MW-3S, from approximately 6,000 ug/L to 200 ug/L (a 97% reduction). The concentration of MTBE in IW-8 was reduced from approximately 500 ug/L to 100 ug/L (80%). The vendor reported that the average reduction for MTBE concentrations throughout the site was 87% for the first 34 days of operation..

Figure 2. Concentrations of MTBE at Connecticut Gas Station - First 34 Days of Operation [3]

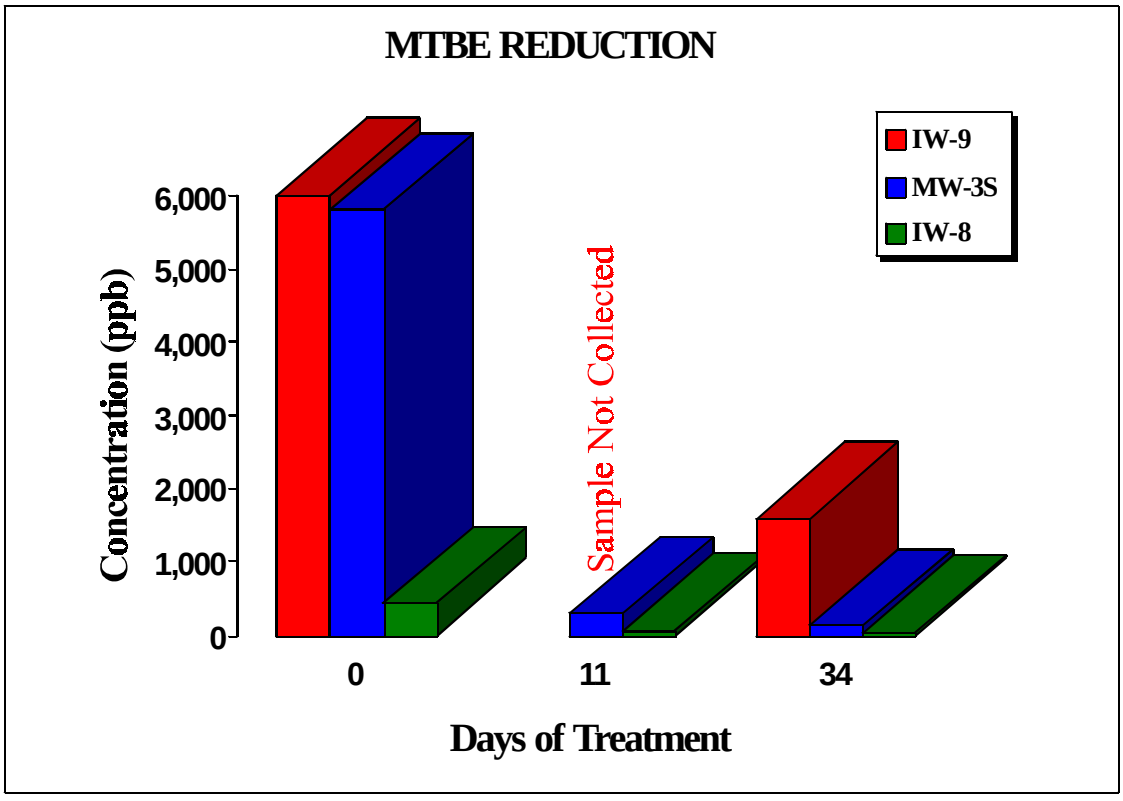
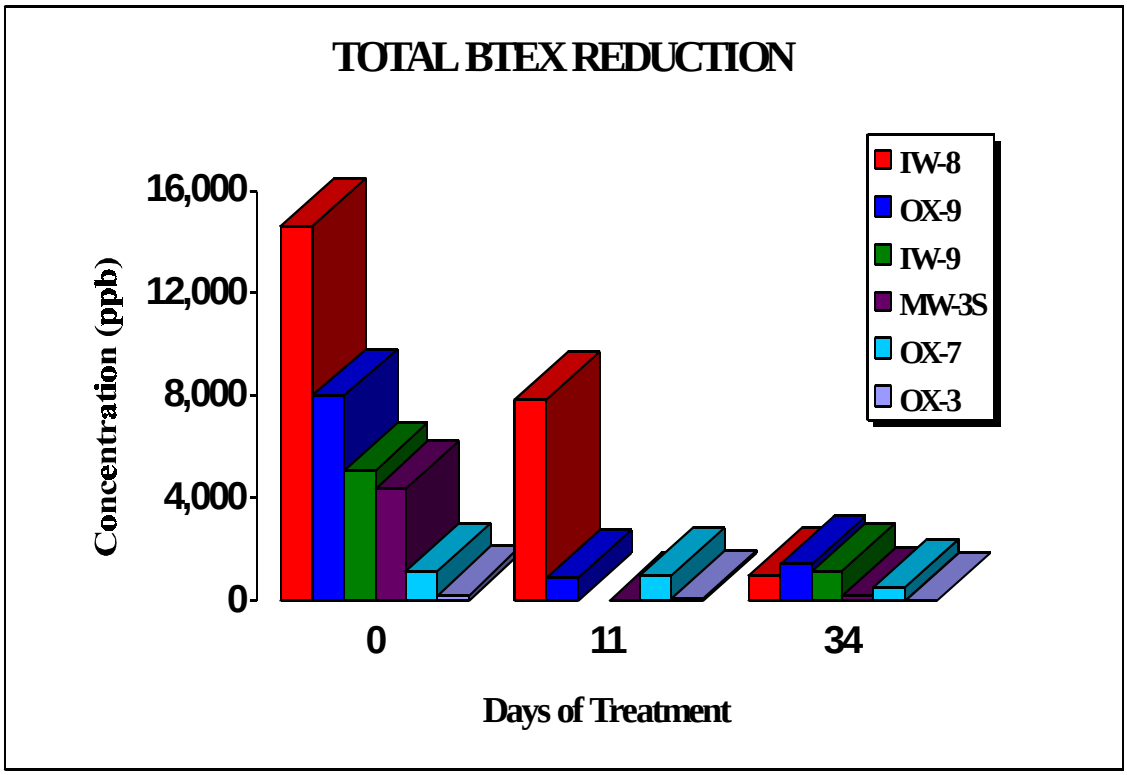


Figure 3. Concentrations of BTEX at Connecticut Gas Station - First 34 Days of Operation [3]



As shown in Figure 3, BTEX concentrations were reduced from as high as 14,000 ug/L (in IW-8) to less than 1,000 ug/L (a 93% reduction). The vendor reported that the average reduction for BTEX constituents throughout the site was 84% during the first 34 days of operation..

Figures 4 and 5 show the changes in BTEX and TPH concentrations over the first 12 months of treatment using *in situ* bioremediation. These figures show a general decrease in concentrations of BTEX and TPH during this 12 month period. Fluctuations in concentrations shown on these figures was attributed by the vendor to seasonal groundwater fluctuations (smear zone contact), contaminant flushing from the soil, and analytical laboratory variance. While data were not provided about the concentrations of MTBE or benzene after 12 months of operation, the data for TPH show that its concentration after 12 months was close to, or slightly above, the cleanup goal of 500 ug/L (shown on Figure 4 as 0.5 ppm).

The vendor reported that the cleanup criteria specified for this site for MTBE, benzene, and TPH were achieved in approximately 18 months of treatment. Information was not available about the concentrations of MTBE, benzene, or TPH after 18 months of operation.

Figure 4. Concentrations of BTEX at Connecticut Gas Station - 12 Months Operation [3]

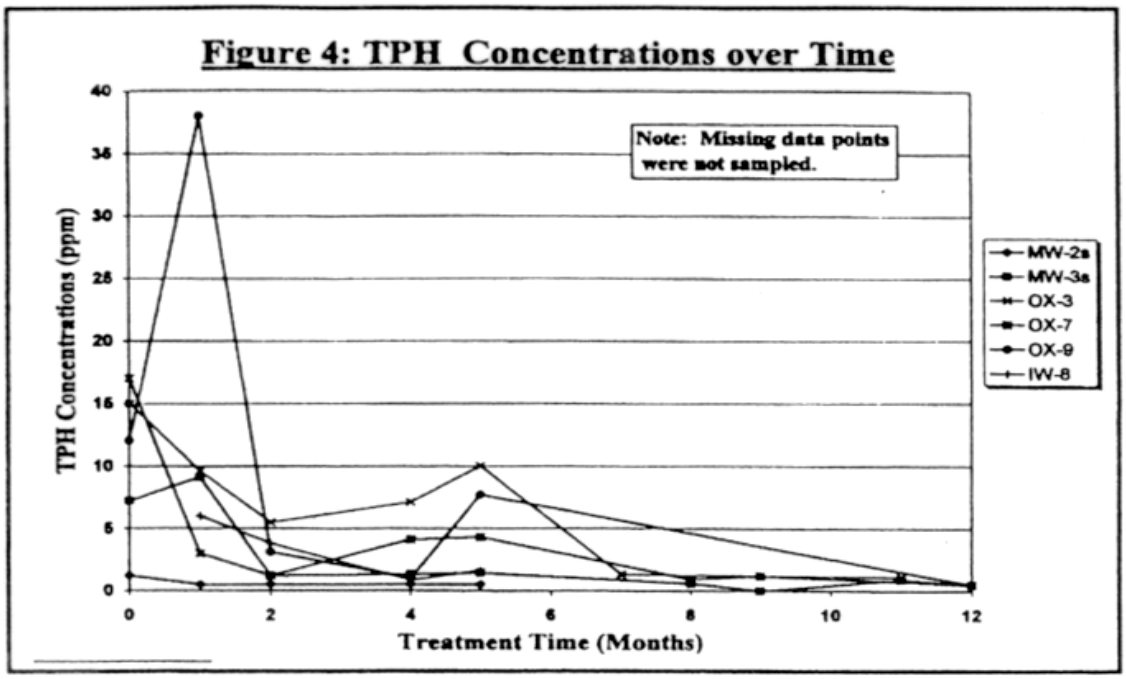
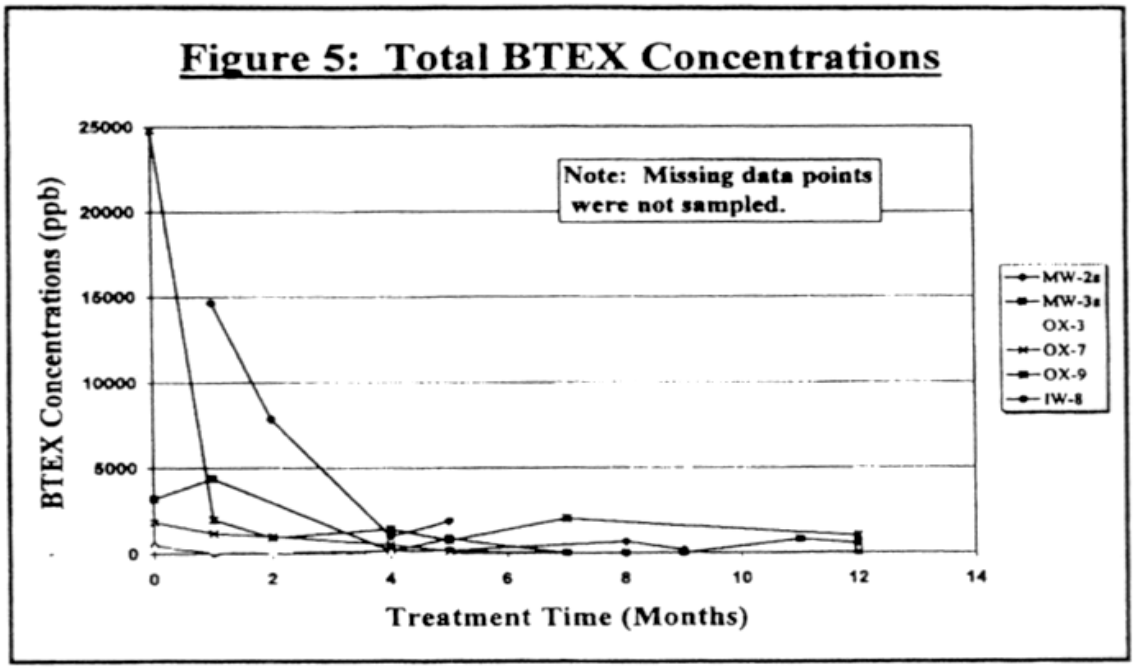
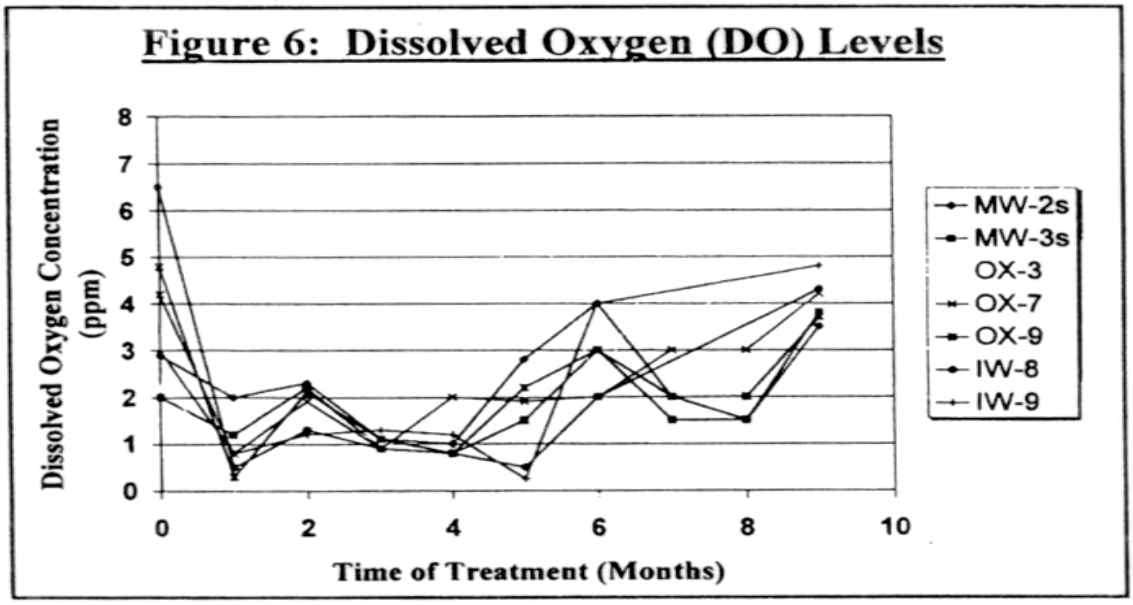


Figure 5. Concentrations of TPH at Connecticut Gas Station - 12 Months Operation [3]



To further assess remedial activity, water quality parameters were measured at this site, including dissolved oxygen, pH, and oxidation-reduction potential. As shown in Figure 6, the dissolved oxygen levels were initially elevated (2 to 6.5 mg/L), especially in the wells closest to the injection points (such as OX-7 and IW-8). Dissolved oxygen concentrations then decreased to less than 2 mg/L and remained relatively low for approximately the next 4 months. The vendor concluded that this dissolved oxygen "sink" indicated a high degree of biological activity, during which rapid oxygen uptake occurred. After this period, the dissolved oxygen concentrations increased, indicating a relatively lower degree of biological activity. The vendor attributed this to a reduced food supply and a degradation of organic contaminants.

Figure 6. Concentrations of Dissolved Oxygen at Connecticut Gas Station - 9 Months Operation [3]



Technology Cost:

Information on the costs for use of *in situ* bioremediation at this site was not provided.

Observations and Lessons Learned [1, 3]:

The concentrations of MTBE and BTEX were reduced by more than 80% during the first 34 days of treatment using *in situ* bioremediation, and cleanup goals were reached within 18 months after treatment began.

According to the vendor, this was the first permitted *in situ* bioremediation project in the state of Connecticut. The relatively shallow depth to groundwater provided for a greater degree of contact between the oxygen, nutrients, and biological products with the contaminants of concern.

References:

1. Brian Clark, P.E., and David Laughlin, Enzyme Technologies, Inc. MTBE and BTEX Degradation Using Enzyme-Catalyzed Dissolved Oxygen In Situ Treatment. Soil & Groundwater. October/November 1999. pp. 21-24

2. Enzyme Technologies, Inc. Partial In Situ Project Listing. Not Dated.

3. Enzyme Technologies, Inc. MTBE and BTEX Degradation Using Enzyme-Catalyzed Dissolved Oxygen In Situ Treatment, Gas Station Site, Cheshire, CT. <www.enzymetech.com/case_studies/cs_mtbe.htm>. August 21, 2000.

4. Brian Clark, P.E., Enzyme Technologies, Inc. E-mail to Doug Maddox, EPA. Comments on Remediation Case Studies. October 10, 2000.