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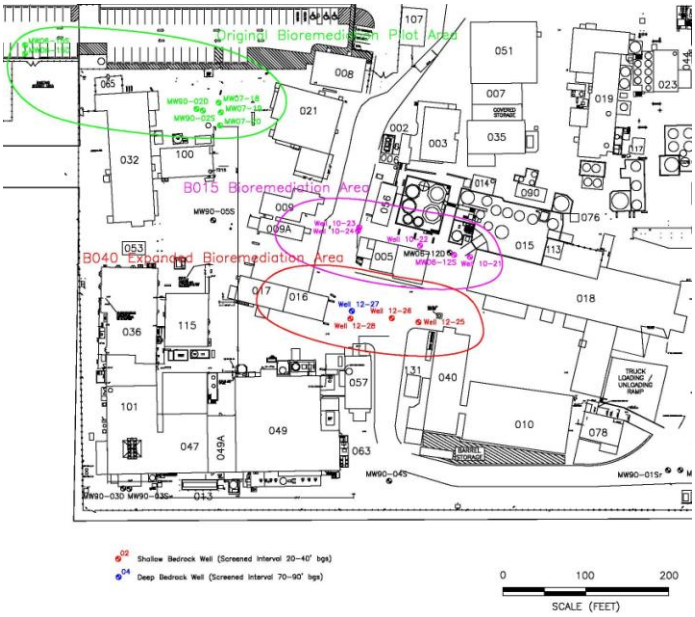
In-Situ Bioremediation Case Study of a Brunswick Shale fractured bedrock site in southeastern PA. using Terra Systems patented large droplet 60% SRS®-FRL Emulsified Vegetable Oil Substrate

A spill of chlorinated solvents was the target of voluntary bioremediation efforts in a Brunswick Shale fractured bedrock site in southeastern PA. The primary groundwater flow is along fractures and weathered bedding planes at a groundwater flow rate estimated to be 20 feet per day. A series of injections have been performed in different areas of the site to promote reductive dechlorination. Figure 1 shows the locations of the treatment areas.

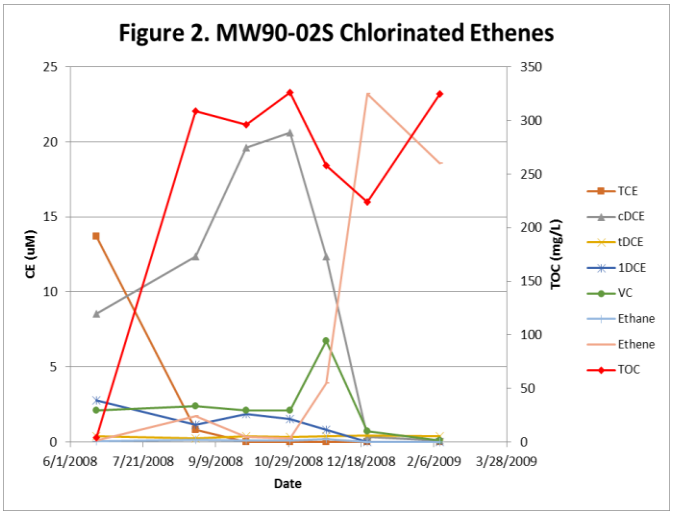
Figure 1. Treatment Areas

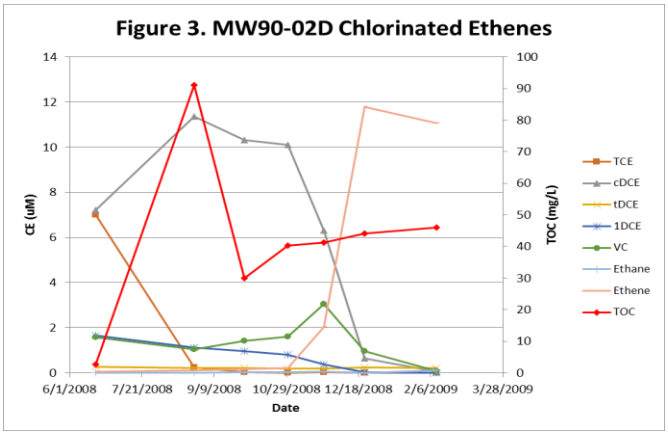


Pilot Area

The first area was a pilot test where 1,800 gallons of diluted 60% SRS®-FRL and 1 g/L of sodium bicarbonate (as a pH buffer) were injected into three injection wells with screens 20 to 90 feet below ground surface (bgs). Four existing observation wells were monitored; MW90-02S and MW06-15S in the shallow zone 20 to 40 feet bgs and MW90-02D and MW06-15D in the deeper zone 50 to 90 feet bgs. The well pair MW90-02S and MW90-02D were about 25 feet from the injection wells and the MW06-15S and 15D were about 275 feet downgradient of the injection wells.

Figure 2 shows the TOC and chlorinated ethenes on a micromolar basis in well MW90-02S and Figure 3 shows the data for MW90-02D. In these wells the TOC levels increased to 91 to 326 mg/L, TCE was converted to cis-1,2-DCE (cDCE), vinyl chloride (VC), and to ethene. However, there was little change in the wells 275 feet downgradient.





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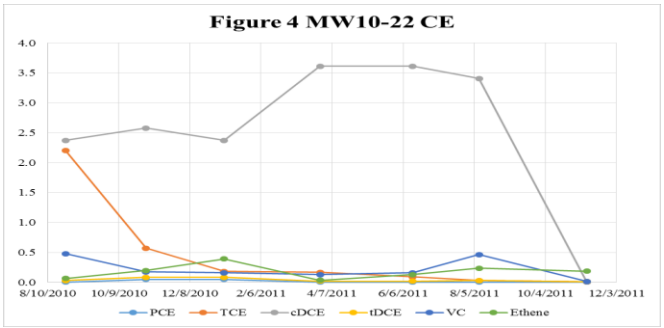
B015 Area

60% SRS®-FRL was injected into this area in October 2010 into Well MW06-12S. Monitoring wells include MW10-21, MW10-22, MW10-23, and MW10-24. As seen in Figure 4, well MW10-22 showed a good response to the 60% SRS®-FRL injections with rapid conversion of TCE to cDCE and later to VC and ethene with ethene the only product found in November 2011. There were conversions of TCE to cDCE and VC also observed in MW10-21, MW10-23, and to a lesser extent in MW10-24, but not completely to ethene as seen in MW10-22.



B040 Area

60% SRS®-FRL was injected in 2012 into the B040 area plume. TOC levels never got very high, with a maximum of 9.1 mg/L in 12-26 (Figure 5). Sulfate concentrations decreased from 63.6 to 33.5 mg/L in MW-12-26, from 43.9 to 29.9 mg/L in MW-12-28, and from 47.5 to 22 mg/L in MW-12-27 (Figure 6). In well MW-12-26, TCE was largely converted to cis-DCE with increases in VC and ethene; ethene and ethane represented 14.7% of the total chlorinated ethenes on a micromolar basis in September 2013 (Figure 7). In well MW-12-27, once again TCE was converted partially to cis-DCE, VC, ethene, and ethane (Figure 8). In September 2013, ethene and ethane represented 51.4% of the total chlorinated ethenes in MW-12-27. Well MW-12-28 showed more limited conversion of TCE to cis-DCE, VC, and a minor quantity of ethene and ethane (only 2% of the total chlorinated ethenes). To promote further degradation in this area, additional 60% SRS®-FRL®-FR should be injected.

The difference in the recommended loadings between the B032 and the B040 areas are primarily related to the difference in treatment thickness (70 feet for the BO32 area versus 20 feet for the B040 area) and sulfate concentrations (103 mg/L for the B032 area and 28 mg/L for B040 area).

Figure 5. TOC in B040 Wells

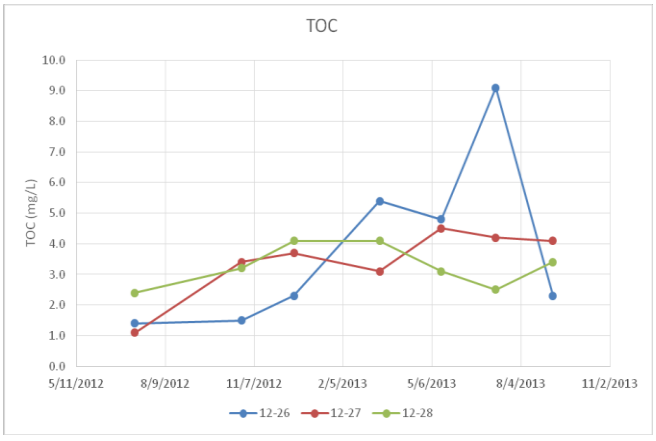


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Figure 6. Sulfate in B040 Wells

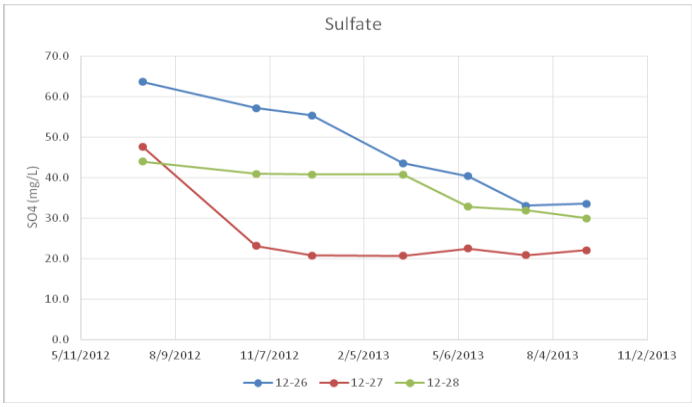


Figure 7. Chlorinated Ethenes (µM) in MW-12-26

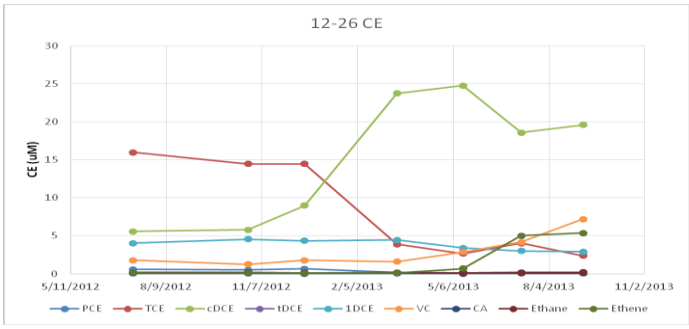


Figure 8. Chlorinated Ethenes (µM) in MW-12-27

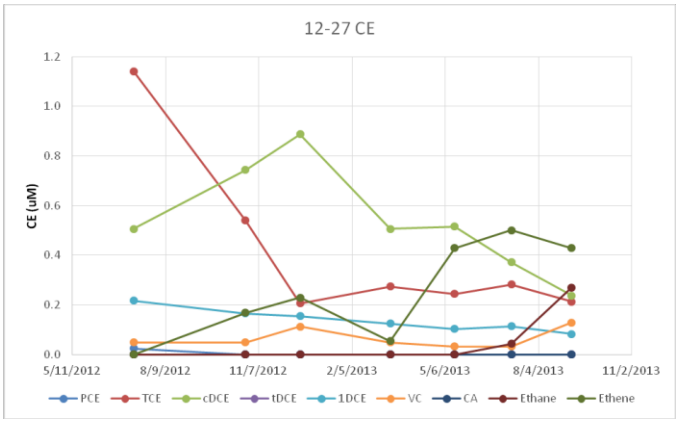
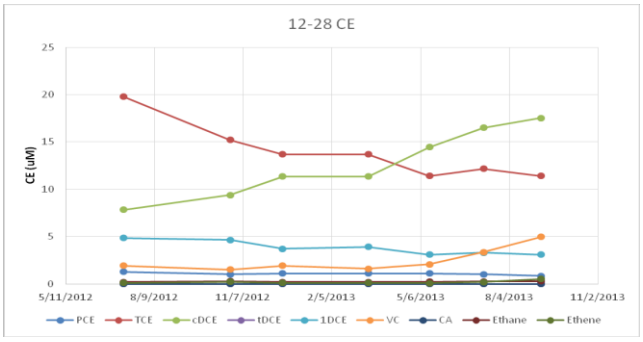


Figure 9. Chlorinated Ethenes (µM) in MW-12-28



B032

60% SRS®-FRL was injected into the Building 32 plume near MW90-5S in Figure 1 in July 2014. No data is yet available.

Conclusions.

Where TOC levels above 10 mg/L were achieved by the injection of the 60% SRS®-FRL-FR, extensive reductive dechlorination of TCE was promoted even under the very high groundwater flow rates.

To discuss this case study in more detail please contact Michael D. Lee, Ph.D., Vice President Research and Development at 302-798-9553 or email him at mlee@terrasystems.net