

Provect-OX® - *In Situ* Chemical Oxidation + Enhanced Bioremediation for Source Area Remediation

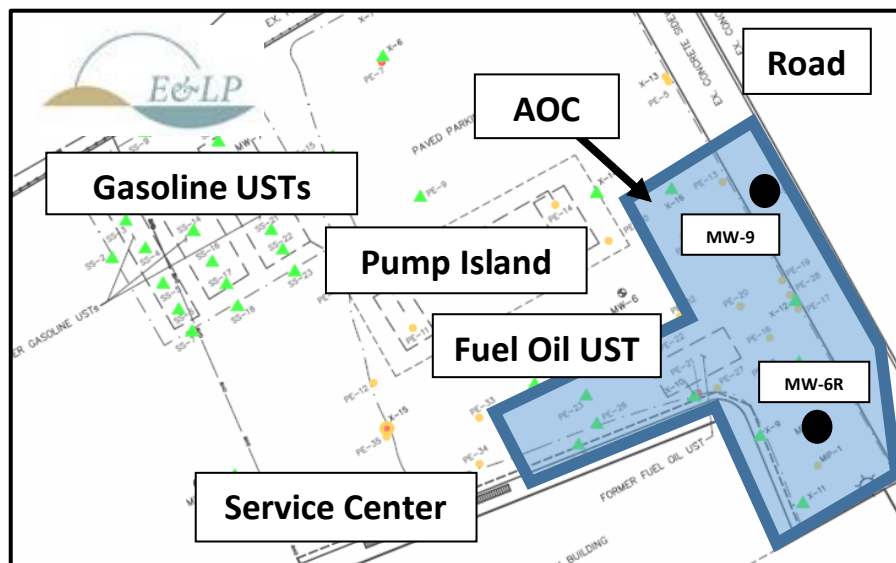
Former Gasoline Station: Madison, New Jersey

Contaminants of Interest: LNAPL, BTEX, and TMB

Project Summary

At a former gas station in Madison, New Jersey, *in situ* remediation was applied to address petroleum hydrocarbon source mass within the subsurface smear and saturated zones. Excavation of gasoline and fuel oil underground tanks (USTs) along with the associated piping and shallow hydrocarbon soil impacts had previously been completed. However, excavation was impacted due to accessibility limitations from the service center building and road. Following excavation and enhanced fluid recovery activities, residual benzene, toluene, ethylbenzene, xylene (BTEX), trimethylbenzene (TMB), and light non-aqueous phase liquid (LNAPL) impacts remained. The primary area of concern (AOC; **Figure 1**) was approximately 1,500 sq ft with a 15-ft vertical target interval from approximately 25 to 40 feet below ground surface (bgs). The geology at the site is dense silt and clay with depth to groundwater at 30 ft bgs. The *in-situ* injection program targeted the BTEX, TMB, and LNAPL with Provect-OX® (US Patent 9,126,245), which is a catalyzed chemical oxidation process that leverages enhanced bioremediation post-oxidation.

Figure 1: Site Map



Remediation Plan

The remedial program was developed by Engineering & Land Planning Associates, Inc. (E&LP) and Provectus Environmental Products, Inc. (Provectus) with *in situ* implementation provided by Innovative Environmental Technologies, Inc. (IET). A total of 13,300 lbs of Provect-OX® were applied via 20 temporary direct push injection locations to treat the AOC and two impacted monitoring wells. The service center remained open and active during drilling and injection activities.

Provect-OX[®] rapidly oxidizes the organic contaminants present in soil and groundwater and provides long-term, sustained secondary bioremediation to manage residuals and prevent contaminant rebound. This is accomplished by using ferric iron (Fe III) as a safe and effective means of activating persulfate, which quickly yields sulfate and ferrate (site-specific) radicals for chemical oxidation treatment. A pH buffer is also preblended with the Provect-OX[®] to offset any post-injection acidic pH conditions that are normally observed with traditional persulfate applications. The technology process enhances subsequent utilization of sulfate and iron as terminal electron acceptors for facultative redox reactions to support secondary biodegradation of any residual contaminant mass.

Treatment Program Results

Field and geochemical data for the two target monitoring wells are presented below in **Table 1** and **Table 2**. Volatile organic compound (VOC) data for the monitoring wells are presented in **Table 3** and **Table 4**. Chemical oxidative conditions are evident during the first MW-6R and MW-9 post-treatment sampling event with increased ORPs of +354 mV and +32.6, respectively. The presence of persulfate, sulfate, and iron in groundwater confirmed that Provect-OX[®] was successfully distributed within the targeted area. The included pH buffer component of the product offset production of sulfuric acid that is created due to persulfate activation (e.g., common persulfate applications exhibit pH <4). During the November 2019 sampling event (3 months post-injection), the ORPs in both wells are negative with transition back to a reducing environment starting to occur.

Table 1. Field and Geochemical Data for MW-6R

MW-6R										
Sampling Date	08/2019 (Baseline)	09/19	10/19	11/19	01/20	02/20	03/20	05/20	08/20	09/21
pH	7.28	-	-	5.92	-	6.35	-	7.03	7.01	6.42
ORP (mV)	-139	+354	+234	-15.8	-21.1	-44	-70	-62	-70	-101
Persulfate (mg/L)	0	70	-	42	21	7	14	0	0	0
Sulfate (mg/L)	ND	-	-	ND	-	1,890	-	980	ND*	720
Iron (mg/L)	7.8	-	-	21	-	34.2	-	18.4	21.7	23.4

*Minimum detection limit of 109 mg/L

Table 2. Field and Geochemical Data for MW-9

MW-9										
Sampling Date	08/2019 (Baseline)	09/19	10/19	11/19	01/20	02/20	03/20	05/20	08/20	09/21
pH	7.21	-	-	6.49	-	6.75	-	7.09	7.05	6.34
ORP (mV)	-102	+32.6	+23.4	-48.4	-47.8	-134	-77	-68	-207	-87
Persulfate (mg/L)	0	0	-	0	0	0	0	0	0	0
Sulfate (mg/L)	ND	-	-	1,170	-	302	-	307	148	1,230
Iron (mg/L)	8.6	-	-	38.3	-	24.0	-	7.88	11.0	24.2

Following the Provect-OX[®] application, petroleum hydrocarbon groundwater concentrations have significantly decreased (**Table 3** and **Table 4**). MW-6R exhibited >89% reduction concentrations for all target VOCs other than ethylbenzene (>68% decrease). The VOC reductions in MW-9 were >88% and LNAPL has been eliminated. Additional contaminant concentration decreases in MW-6R and MW-9 are anticipated due to the iron and sulfate enhanced bioremediation processes.

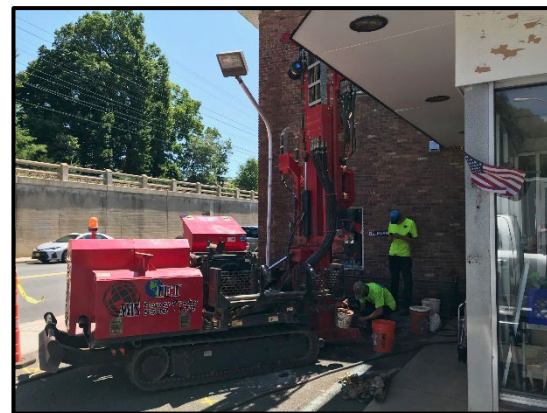
Table 3. VOC Data for MW-6R

MW-6R							
Sampling Date	08/2019 (Baseline)	11/19	02/20	05/20	08/20	09/21	Reductions
Benzene (µg/L)	0.129	0.732	0.698	0.560	ND	0.129	-
Ethylbenzene (µg/L)	2,510	279	489	1,270	906	784	68.8%
Total Xylenes (µg/L)	5,910	388	123	103	33	621	89.5%
Toluene (µg/L)	1,790	140	6	15	45	2.5	99.9%
1,2,4-Trimethylbenzene (µg/L)	5,460	22	162	430	134	56.6	99.0%

ND: Non-Detect

Table 4. VOC Data for MW-9

MW-9							
Sampling Date	08/2019 (Baseline)	11/19	02/20	05/20	08/20	9/21	Reductions
Benzene (µg/L)	29.7	14.2	9.7	10.3	6.5	3.56	88.0%
Ethylbenzene (µg/L)	1,590	1,200	331	1,140	279	115	92.8%
Total Xylenes (µg/L)	6,280	4,070	1,130	1,610	360	84.2	98.7%
Toluene (µg/L)	7,680	3,690	628	198	52.6	53.3	99.3%
1,2,4-Trimethylbenzene (µg/L)	5,670	3,870	600	2,520	882	357	93.7%



Please contact our office at (815) 650-2230 or via email at info@provectusenv.com for additional information regarding this project or our technologies.