# *In Situ* Bioremediation Using ORC®
# at an Active Service Station, Southern California

**Site Name:** Service Station (actual name confidential)

**Site Location:** Southern California

**Contaminants:** MTBE, BTEX

**Media:** Groundwater

**Technology:** *In Situ* Bioremediation using ORC®

**Technology Scale:** Full

**Cleanup Type:** Not provided

**Period of Operation:** Not provided

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**Site History [1]:**

The site is an active gasoline service station located on the coast of southern California, at the mouth of San Juan Creek Valley, about one-third of a mile north of the Pacific Ocean. In the early 1990's, two underground gasoline storage tanks were replaced and soil contaminated with petroleum hydrocarbons was found beneath the tank cavity and one of the gasoline dispenser islands. Total petroleum hydrocarbon (TPH) concentrations were found in soil at levels up to 9,000 mg/kg. In groundwater, BTEX (benzene, toluene, ethylbenzene, and xylenes) compounds were found at levels as high as 25,000 ug/L for benzene, and MTBE was found at levels as high as 13,000 ug/L. There are two dissolved-phase plumes at the site, BTEX and MTBE.

The soil at the site consists of silts and clays to a depth of approximately 20 feet below ground surface (bgs), and silty, fine-grained sands to medium-grained sands in the saturated zone. The direction of groundwater flow at the site is west to southwest at an average gradient of 0.0037 ft/ft and velocity of 0.067 to 0.24 ft/day. The quality of the groundwater in the area of the site is classified as poor due to high concentrations of dissolved solids. Groundwater at the site contains chloride at a concentration of 950 mg/L and total dissolved solids at a concentration of 4,700 mg/L. In the mid-1990's, soil vapor extraction (SVE) was used at the site for approximately 13 months. While data on SVE performance was not provided, the technology did not have a long-term impact on the concentrations of dissolved-phase hydrocarbon in the saturated zone, and fuel remained adsorbed to soil within the vadose zone.

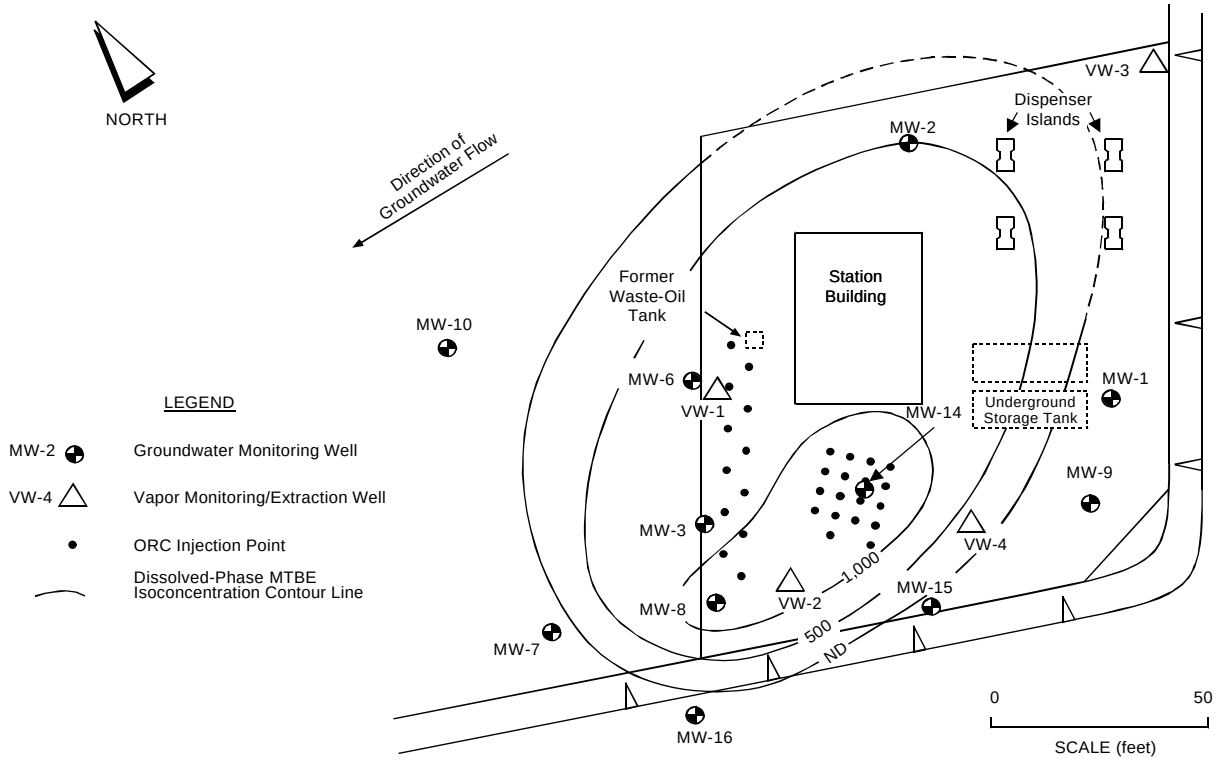
Oxygen Release Compound (ORC®) was injected at the site to reduce the dissolved-phase concentrations of BTEX and MTBE and to contain the contaminant plume. Factors considered prior to injection of ORC® at the site included groundwater velocity, biological oxygen demand, soil texture, porosity, pH, temperature, and the concentrations of alternate electron receptors. These factors were determined to be within an acceptable range, however, the salinity of the groundwater was a concern. While the oxygen release rate of ORC® is normally expected to last about six months, the brackish nature of the groundwater was expected to reduce this by as much as 50%.

**Technology Description [1]:**

ORC®, a magnesium peroxide compound, was injected into the source area and at the down-gradient property boundary to increase the concentration of dissolved oxygen (DO) in the subsurface and enhance the biodegradation of petroleum hydrocarbons, including benzene and MTBE. A total of 750 pounds of ORC® was injected through 18 direct-push bore holes located within the source area by pushing hollow rods with removable tips to a depth of 28 ft, and then pumping ORC®-slurry through the rods as they were raised from a depth of 28 ft to 18 ft. An additional 150 pounds of ORC® was injected through 12 direct-push bore holes located at the property boundary.

Figure 1 is a site map that shows the location of the MTBE plume at the site and the ORC® injection points.

**Figure 1. Site Map [1]**



**Technology Performance [1]:**

To monitor the effectiveness of the ORC® injections, groundwater samples were collected from representative monitoring wells prior to injection and then approximately monthly for five months after injection. Samples were analyzed for TPH, BTEX, MTBE, and other parameters. Table 1 summarizes the analytical results for Monitoring Well 14 (MW 14), which is located within the source area, as shown on Figure 1. Day "0" is the day ORC® was injected, with samples collected just prior to injection.

**Table 1. Chemical and Physical Groundwater Properties Measured for MW-14 [1]**

| Time (days) | TPH (ug/L) | Benzene (ug/L) | Toluene (ug/L) | Ethyl-benzene (ug/L) | Xylenes (ug/L) | MTBE (ug/L) | Ground-water Elevation (ft) | DO (mg/L) | Oxidation/ redution Potential (mV) |
|---|---|---|---|---|---|---|---|---|---|
| -369 | ND | 9,000 | 1,000 | 1,600 | 2,100 | 6,700 | 9.22 | NR | NR |
| -223 | 35,000 | 9,900 | 2,000 | 1,400 | 1,100 | 5,000 | 9.20 | NR | NR |
| -145 | 34,800 | 9,640 | 2,530 | 2,020 | 1,390 | 4,600 | 9.37 | NR | NR |
| -63 | 38,000 | 10,000 | 4,800 | 1,600 | 1,700 | 2,100 | 9.99 | NR | NR |
| **0 (ORC Injected)** | **33,000** | **11,000** | **1,200** | **1,900** | **2,500** | **2,200** | **10.02** | **0.0** | **NR** |
| 31 | 5,200 | 2,400 | 12 | 260 | 350 | 510 | 10.78 | 0.0 | -246 |
| 65 | 3,800 | 2,500 | 6.4 | 200 | 280 | 410 | 8.95 | 0.0 | 33 |
| 74 | 3,600 | 13,000 | 6,300 | 2,600 | 3,200 | 1,800 | 9.78 | NR | NR |
| 100 | 27,000 | 9,400 | 3,000 | 920 | 1,600 | 1,700 | 9.48 | 0.0 | -201 |
| 134 | 28,000 | 9,600 | 1,800 | 1,200 | 1,700 | 1,300 | 9.18 | 0.0 | -322 |
| 155 | 47,000 | 15,000 | 6,400 | 2,400 | 4,100 | 2,300 | 9.20 | NR | NR |

For the first two months following the injection of ORC®, MTBE, BTEX constituents, and TPH concentrations in well MW-14 decreased and the oxidation/reduction potential increased to a positive value, indicating an increase in the oxidation conditions in the subsurface. However, after the second month, concentrations of MTBE, BTEX constituents, and TPH rose to pre-injection levels and the oxidation/reduction potential decreased to a negative number. By the fifth month (day 155), concentrations of MTBE, BTEX constituents, and TPH were above pre-injection levels (day -63).

Several possible reasons were cited for the increases in concentrations after two months, including: 1) actual dissolved fuel hydrocarbon concentrations may have been higher than expected, exhausting the oxygen before all hydrocarbons were metabolized; 2) the elevated salinity of the groundwater may have caused the DO to be released at a rate higher than could be used by existing site microbes; and 3) fuel hydrocarbons which remained adsorbed to the soil particles in the capillary fringe may have provided a source to reintroduce hydrocarbons in the dissolved phase.

**Technology Cost:**

No cost information for this application was available.

**Observations and Lessons Learned:**

The application of ORC® at the Southern California site initially reduced contaminant concentrations in the groundwater for MTBE, BTEX, and TPH. However, after five months, contaminant concentrations began to rise above the pre-injection levels. Possible reasons for the increase in concentration included the presence of a continuing source of hydrocarbons and subsurface conditions that adversely affected the existing microbes at the site.

**References:**

1. Stephen T. Defibaugh and Daniel S. Fischman. Biodegradation of MTBE Utilizing A Magnesium Peroxide Compound: A Case Study. In Situ Bioremediation of Petroleum Hydrocarbon and Other Organic Compounds. Battelle Press. Bruce C. Alleman and Andrea Leeson, editors. The Fifth International In Situ and On-Site Bioremediation Symposium, San Diego, California, April 19-22, 1999.