SOURCE REDUCTION FOR NATURAL ATTENUATION USING TWO-PHASE EXTRACTION

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ABSTRACT:

This paper presents the results of a case study using Bubblex[SM1] two-phase extraction (BTPE) method for removal of hydrocarbons for preparing the site for development by risk based closure or natural attenuation. The site selected for this study is located in Orange County, California, where a release from an undergroun storage tank (UST) occurred. Fourteen (14) groundwater wells were installed on-site for periodic monitoring. A 90-day BTPE pilot test began in mid January of 2000. Initially two wells (EW-1, EW-2) were connected to the extraction system.

The BTPE involved the use of vacuum developed in the extraction system to draw water and vapor, through an extraction pipe. The extraction pipe was open to the screened portion of the well. The BTPE created turbulent flow in the extraction pipe stripping volatile organic compounds (VOC's) from the water. These vapors were subsequently destroyed in the catalytic oxidizer. The extracted water was polished by two carbon vessels and discharged to the storm drain under National Pollution Discharge Elimination System (NPDES) permit guidelines.

Each month, all wells were sampled for Total Petroleum Hydrocarbon as Gasoline (TPH-G), benzene, toluene, ethyl-benzene, and xylene (BTEX). Vacuum in inches of water column (W.C.) and depth to water in each well were measured on a weekly basis, in order to monitor the vacuum response and the capture zone at the site.

During the first two months of operation, approximately 72,000 gallons of groundwater were extracted and remediated. After two months of operation, three additional groundwater wells and two vapor wells were connected to increase the recovery rate and zone of influence of the treatment cell. By the end of the third month, all wells showed a significant reduction in benzene concentrations in groundwater. Benzene concentrations in two of the wells (MW-1 and MW-9) dropped from 6,000 parts per billion (ppb) to less than 1 ppb, and 260 ppb to less than 1 ppb, respectively. All but two wells (MW-5 and MW-6) showed a marked decrease in total petroleum hydrocarbons as gasoline (TPH-G) concentrations in groundwater.

After operation of the BTPE system for six months a rebound test also performed. The results of the rebound test indicated that static vapor and water concentration in wells after 15 days of non-operation were low enough to consider risk based closure and/or natural attenuation for the remaining hydrocarbons.

[1] Bubblex is a service mark of Tait Environmental Management, Inc. for Bubbling Extraction Method, a patented method (Patent No. 5,906,204) for extraction and in-well stripping of volatile organic compounds

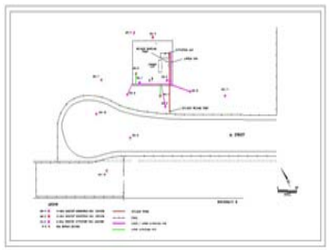

Figure 1. Site Plan

SITE SETTING

The site is located in the Oranga County, California. The site was used as a car dealership prior to 1992. A 2000 gallon unleaded gasoline underground storage tank was used to fuel the cars on site. The tank was removed in 1988. During tank removal contaminated soil and shallow groundwater was encountered. The light non-aqueus phase liquid (LNAPL) layer as thick as 4 feet observed in the groundwater wells. Passive LNAPL recovery was performed for over 7 years until the LNAPL was completely removed from the wells. A shallow perched groundwater was encountered in the silty sand and sand zone at 10 feet bgs. A clay layer, over 5 feet thick with permeability less than $1.0X10^{-7}$ cm/sec, underlies the perched shallow groundwater zone at 20 feet bgs. The natural groundwater flow is to the west with a mild gradient of 0.006.

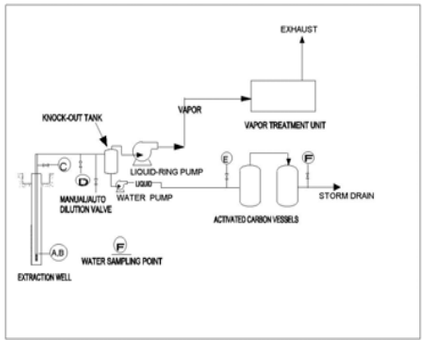

Figure 2. Typical Two-Phase Extraction System Schematic. A positive displacement blower was used in lieu of the liquid ring pump shown.

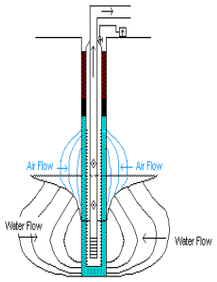

Figure 3. Bubblex[SM] Well

Figure 4. Bubblex[SM] Wellhead

METHOD DESCRIPTION

The Bubblex[SM] method allows a limited amount of air/vapor from the unsaturated zone and a limited amount of water from the saturated zone to enter the extraction pipe through a modified screen. Both vapor and water flow in a combined stream within the extraction pipe until it reaches the separation tank. The new design of the extraction pipe screen facilitates lifting water from depths greater than 33 feet, extracting vapor from the vadose zone and stripping volatile hydrocarbons from the extracted water. The extracted water and vapor are then separated in a separation tank. The vapor is sent to a thermal/catalytic oxidizer, and the water is discharged through an granulated activated carbon (GAC) polishing unit to a storm drain under a National Pollution Discharge Elimination System (NPDES) permit.

Figure 5. Sediment Trap

A sediment trap was installed upstream of the knockout tank in order to capture the sediments before entering into the knockout tank. The sediment trap was connected to the knockout tank in two ways. One connection was from the top allowing the vapor flow into the knockout tank and another connection was near the bottom for the water.

The wellheads were raised to allow the extracted water to drain under gravity into the sediment trap and knockout tank. This change reduced the friction loss in the horizontal pipe, increased vacuum at the wellhead and increased recovery rate of groundwater. Approximately 246,000 gallons of water were extracted during six months of operation.

Figure 6. Sediment Trap and raised piping

Figure 7. System Operation Data

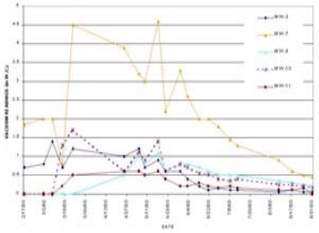

Figure 8. Vacuum Readings in Observation Wells.

FINDINGS

Observed vacuum readings showed a declining trend as the water level drawn down bacause a larger vadose zone created by dewatering was available for vapor flow. An estimated total of 1375 lbs of hydrocarbon was extracted through the vapor stream. The hydrocarbon removed in vapor stream includes the hydrocarbons that stripped off from the water during extraction.
Approximately 6 lbs of hydrocarbons were adsorbed by the granular activated carbon. Due to stripping in the extraction pipe the carbon use was minimal.

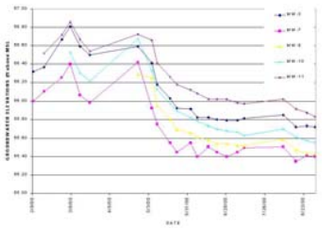

Figure 9. Groundwater Elevations in Observations Wells.

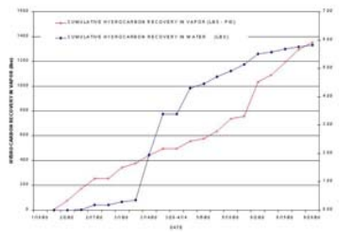

Figure 10. Cumulative Hydrocarbon Removal in Water and Vapor

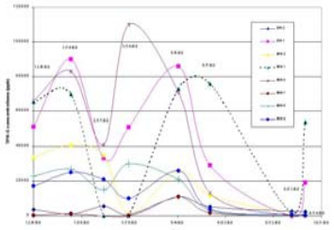

Figure 11. TPH-G Concentrations in Groundwater

The total petroleum hydrocarbons as gasoline (TPH-G) and benzene concentrations in groundwater declined as the system continued to operate. When the system was started, only two extraction wells (EW-1 and EW-2) were operating. In March 2000, three monitoring wells (MW-5, MW-6, and MW-9) were also connected to the system to enhance the water and vapor removal. The system was shut down for two weeks to see the rebounding concentrations in August 2000. The TPH-G concetrations in two wells (MW-1 and EW-1) increased after two weeks of non-operation. TPH-G concentraions in all the other wells and benzene concentrations in all wells remained low after the rebound test.

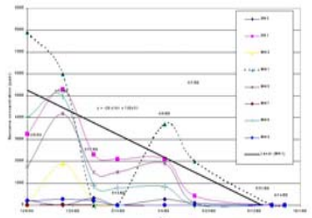

Figure 12. Benzene Concentrations in Groundwater

CONCLUSIONS

The two-phase extraction was effectively applied at this site without using a liquid ring pump or high vacuum.

Elevating the extraction pipes and having water flow into the knockout tank under gravity drainage, increased the recovery of water and reduced the friction loss in the extraction pipe

The carbon use was minimal due to stripping in the extraction pipe.

The two-phase extraction method was able to reduce elevated benzene and TPH-G concentrations in groundwater significantly.