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 in preparation of site 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 underground storage tank (UST) occurred. Fourteen (14) groundwater wells were installed on-site for periodic monitoring (Figure 1). 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 pipe was open to the screened portion of the well, which allowed the BTPE to create turbulent flow, 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 treated. 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 completion of first 90-day test, BTPE test was continued for additional 90 days to extend the observed significant reductions in hydrocarbon concentrations in groundwater.

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

After operating the BTPE system for six months, a rebound test was 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 final phase of cleanup. Currently, site closure monitoring is being performed to obtain final closure from the regulatory agency.

INTRODUCTION

The purpose of this paper is to provide a case study of Bubblex^{SM} two-phase extraction-stripping (BTPE) method used for source reduction. The uniqueness and interest to the scientific community of this case is that a new method of two-phase extraction was used with some enhancements, which allowed us to use a low vacuum system for extraction and stripping of volatile hydrocarbons (VOCs).

SITE SETTING

The site is located in the Orange 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. A light non-aqueous phase liquid (LNAPL) layer as thick as 4 feet was observed in the groundwater wells. Passive LNAPL recovery was performed for over 7 years until the LNAPL was completely removed from the wells. Shallow perched groundwater rests 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.

REMEDIATION PROCESS

BTPE method was used to cleanup both soil and groundwater at this site. The BTPE method allows a limited amount of air/vapor from the unsaturated zone and a limited amount of water from the saturated zone to enter an extraction pipe through a patented, modified screen (Pehlivan et al, 1999). Both vapor and water flow in a combined stream within the pipe until it reaches the separation tank. The new design of the extraction pipe screen facilitates lifting water from depths greater than 33 feet (10.06 meters), extracting vapor from the vadose zone, and stripping VOCs from the extracted water. Up to 99% of VOCs stripping efficiencies were observed in the extraction pipe during previous studies (Pehlivan et al, 2000a and 2000b). The method allowed the use of a vacuum blower with a capacity of 120 inches of water column vacuum to extract water up to 5 gpm and vapor up to 200 cfm at this site. The extracted water and vapor were then fed into a separation tank. The vapor is sent to a thermal/catalytic oxidizer, and the water is discharged through a granulated activated carbon (GAC) polishing unit to a storm drain under a National Pollution Discharge Elimination System (NPDES) permit. The extraction

piping was modified to allow water to drain under gravity flow into the air/water separation tank after extraction from the wells. This modification reduced the friction loss in the horizontal pipes and greatly increased the recovery of groundwater.

FINDINGS

Observed vacuum readings showed a declining trend as the water level was drawn down because a larger vadose zone was available for vapor flow (Figure2). An estimated total of 1375 lbs of hydrocarbon was extracted through the vapor stream. The hydrocarbon removed in the vapor stream included the hydrocarbon that stripped off from the water during extraction (Figure 3). Approximately 6 lbs of hydrocarbon was adsorbed by the granular activated carbon. Due to stripping in the extraction pipe, the carbon use was minimal.

The total petroleum hydrocarbon 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 rebound concentrations in August 2000. The TPH-G concentrations in two wells (MW-1 and EW-1) increased after two weeks of non-operation. TPH-G and benzene concentrations in most wells remained below 1000 and 10 micrograms per liter (ug/l) respectively after the rebound test. The average benzene concentrations remained below 10 ug/l in groundwater as observed in quarterly groundwater samples collected on December 7, 2000, three months after the system shut down (Figure 4).

CONCLUSIONS

Our conclusions can be summarized as follows:

- 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 concentrations of benzene and TPH-G in groundwater significantly to consider site closure.

ACKNOWLEDGMENTS

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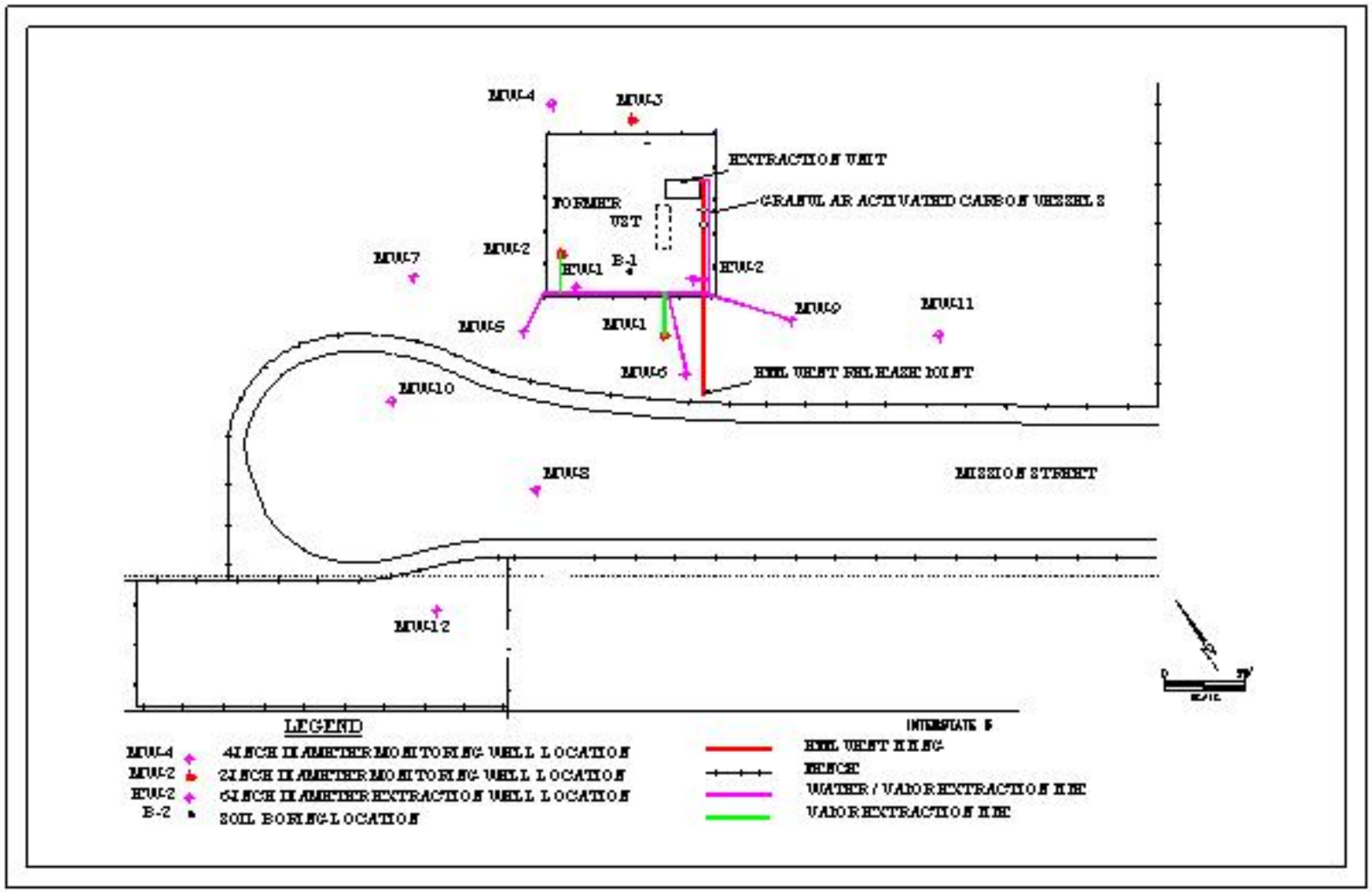


FIGURE-1 SITE PLAN

FIGURE 2 - VACUUM READINGS IN OBSERVATION WELLS

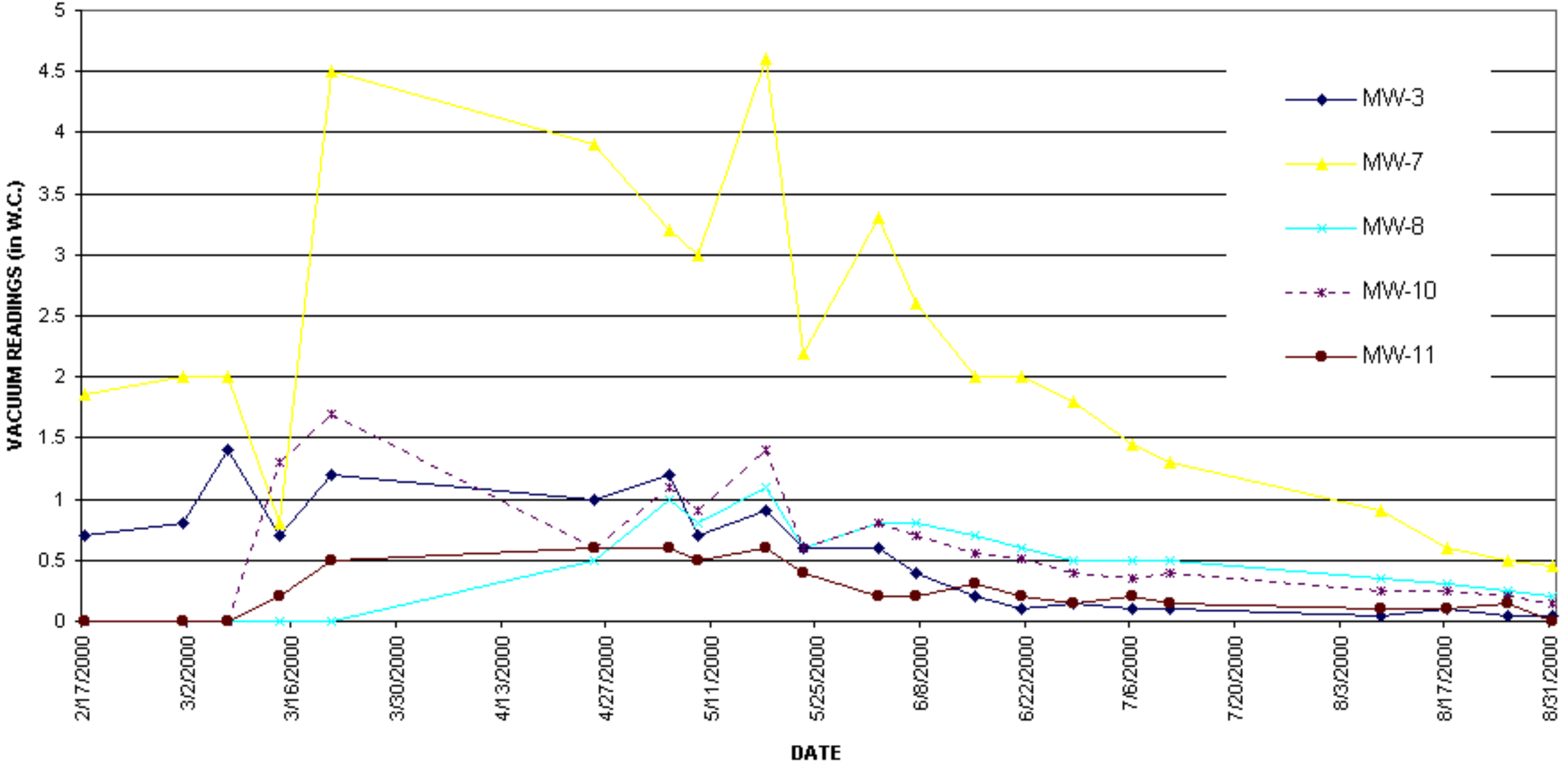


FIGURE 3 - CUMULATIVE HYDROCARBON RECOVERY

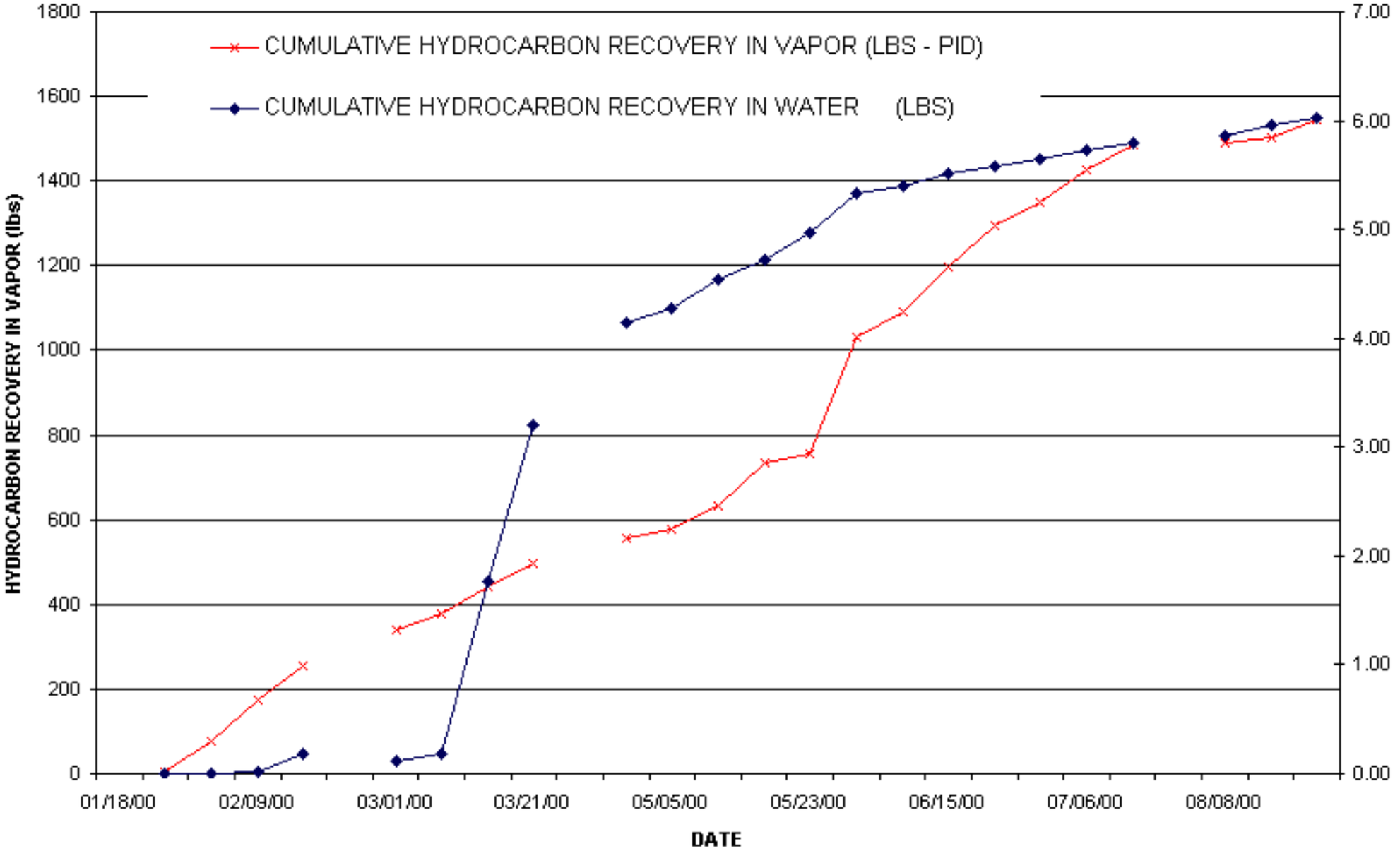
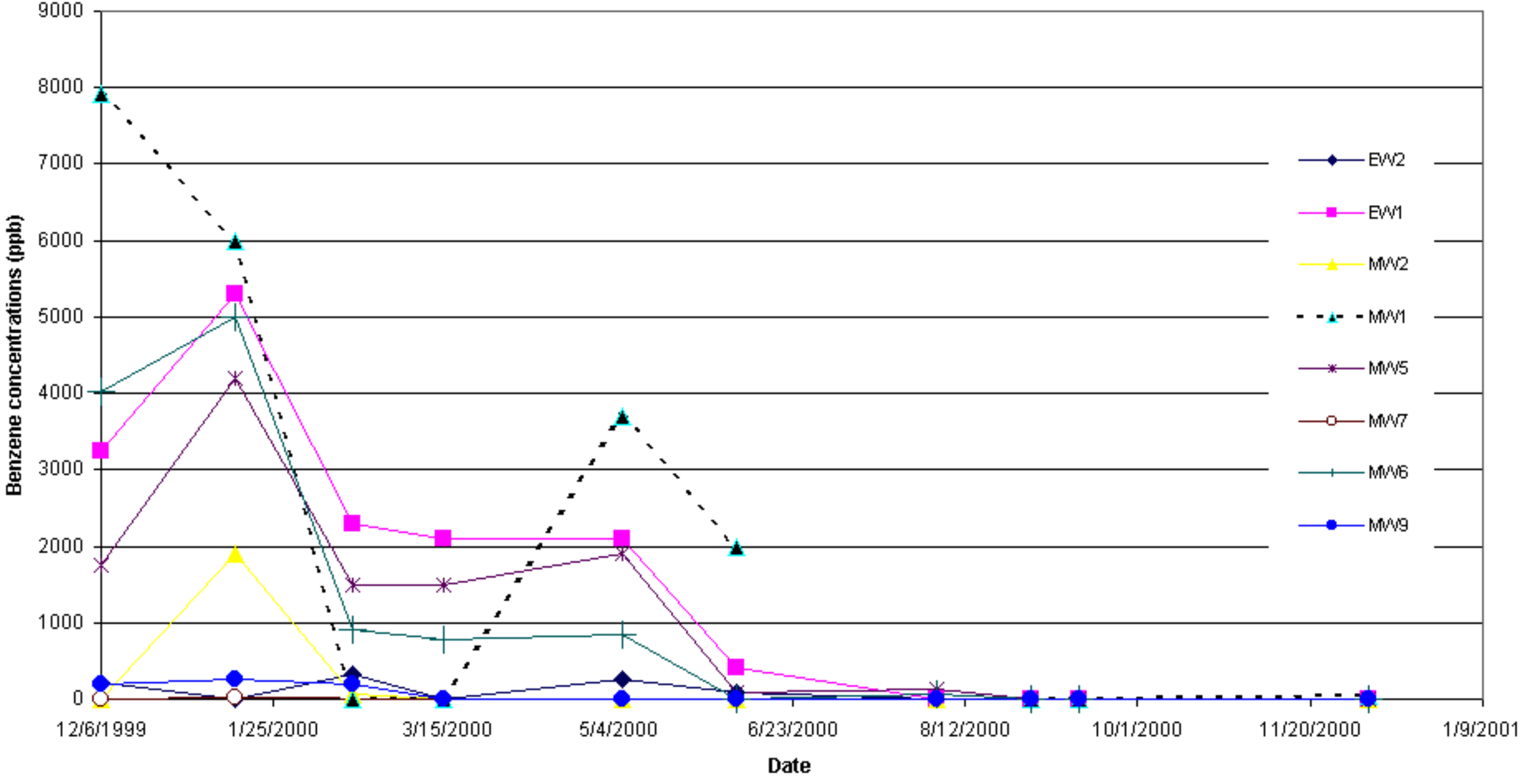


FIGURE 4 - BENZENE CONCENTRATIONS IN GROUNDWATER



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Mr. Pehlivan is a co-inventor of Bubblex^{SM} System. He has personally performed over ten pilot tests and oversaw the installation and operation of two full-scale two-phase extraction systems. He is in the process of installing several other systems at sites with elevated concentrations of MTBE and other volatile compounds. He has over 23 years of combined professional experience as a hydrogeologist and a petroleum reservoir/production geologist. He is a Certified Hydrogeologist in California, Registered Geologist in California and Arizona.