Groundwater Flow Monitoring and Plume Evolution

Preston D. Jordan, Curtis M. Oldenburg, and Grace W. Su
Contact: Preston D. Jordan, 6774, PDJordan@lbl.gov

RESEARCH OBJECTIVES

In the mid-1990s, investigators observed transgradient expansion of the groundwater plume of halogenated, aliphatic volatile organic compounds (VOCs) at Operational Unit 1 (OU-1) of the former Fort Ord Army Base in Monterey, California. Additionally, the plume was found to extend considerably farther in a downgradient direction than determined in the initial characterization performed during the late 1980s. A possible second contaminant release site was posited to explain this latter observation. The objective of this project was to use advanced flow and analyte monitoring instrumentation, efficient data management and analysis, and numerical modeling to understand the evolution of the OU-1 plume.

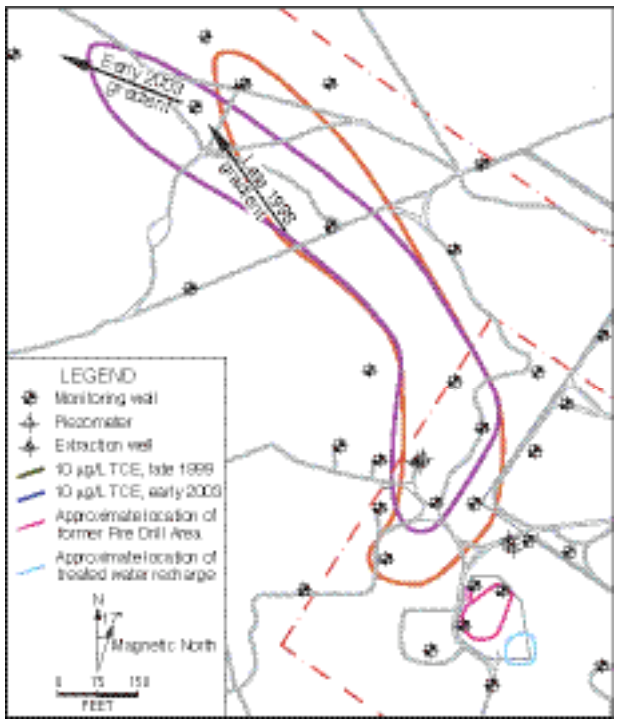

Figure 1. Gradient rotation and extent of trichloroethylene (TCE) plume greater than 10 µg/L after historically intense precipitation in early 1998 at OU-1, Former Fort Ord Army Base

APPROACH

Well-log, water-level, and chemistry data were provided by the groundwater monitoring contractor for OU 1, MacTec Engineering and Consulting, Inc. Treatment system totalizer data were provided by the remedial contractor, AHTNA Government Services, Inc. To improve analysis efficiency, and therefore insight, water-level and chemistry data were loaded into the environmental information management system software (EIMS) GIS\Key (produced by GIS Solutions, Inc.), which integrates data management with graphing and mapping. Precipitation data for the area were obtained from the National Oceanic and Atmospheric Administration (NOAA) National Data Center and incorporated into the analysis. We installed five Hydrotechnics heat-based *in situ* flow sensors to measure well-scale groundwater flow velocities (magnitude and direction). In addition, we carried out short-duration pump tests to measure hydraulic conductivity.

The data set aggregated from the above activities was analyzed to determine the hydrogeologic structure, precipitation recharge rates, hydraulic gradient, contaminant concentrations, porosity, and hydraulic conductivity distribution, orientation, and scaling. A conceptual model of the relationship between these parameters was tested through numerical modeling.

ACCOMPLISHMENTS

The hydraulic conductivity of the aquifer materials was found to be remarkably uniform across scales, orientations, and locations. The numerical modeling demonstrated that the entire OU-1 plume evolved from one contaminant release site. Concentration trend analysis indicated that treated water recharge occurred within the plume area and therefore caused transgradient expansion of the plume. Water-level analysis revealed that gradients in the distal portion of the plume rotated counterclockwise upwards of 30° in response to historically intense precipitation in early 1998 (see Figure 1). Concentration trend analysis further revealed advection of the distal portion of the plume oblique to the plume axis, as expected because of the plume rotation.

SIGNIFICANCE OF FINDING

The rotation of the plume at OU 1 has profound implications. One implication is the need for a significantly expanded well field to monitor and remediate the plume over time as it rotates. These results demonstrate the value of an integrated approach to plume monitoring that includes flow sensors for local groundwater velocity measurement, increased efficiency of data analysis provided by an EIMS, and numerical simulation.

RELATED PUBLICATIONS

Jordan, P.D., C.M. Oldenburg, and G.W. Su, Analysis of aquifer response, groundwater flow, and plume evolution at Site OU 1, former Fort Ord, California. Berkeley Lab Report LBNL-57251, February 2005.

ACKNOWLEDGMENTS

This work was supported by University of California Santa Cruz through the U.S. Army Construction Engineering Research Laboratories under Contract No. DACA42-02-2-0056, and by the U.S. Department of Energy under Contract DE-AC03-76-SF00098.