Phytoremediation System Cleans up Groundwater Plume

By Mr. John Wrobel

The Department of Safety, Health, and the Environment at Aberdeen Proving Ground (APG), Maryland, joined with the US Environmental Protection Agency (EPA) almost 8 years ago to implement an innovative solution to remediating an area of groundwater contamination. In 1996, APG and EPA began a pilot-scale phytoremediation study at the J-Field area of APG to evaluate the capability of hybrid poplar trees to reduce a volatile organic compound (VOC) groundwater plume. Eventually implemented as part of the legal remedial alternative for the site, the phytoremediation system has proven to be an effective, low-cost solution to groundwater contamination.

Background

Between 1940 and the 1970s, the Army used J-Field for testing and disposal of chemical weapons and chemical warfare materials. Environmental studies indicated high levels of a variety of VOCs in the groundwater. The two primary contaminants are trichloroethylene (TCE) and 1,1,2,2-tetrachloroethane. Several conventional remedial technologies were studied or tested during the remedial investigation/feasibility studies, including soil washing, soil vapor extraction, pump and treat, and groundwater circulation wells, as well as in situ biotic and abiotic degradation processes. However, there are several unique aspects of the J-Field area that significantly hinder the use of conventional technologies. For example, because of historic testing and disposal activities, there is a potential that unexploded ordnance (UXO) may be present. In addition, there is a low-permeability aquifer and a persistent VOC source consisting of dense non-aqueous-phase liquids. During evaluation of remedial alternatives, APG became aware of the work of the EPA Environmental Response Team in the area of phytoremediation. EPA had been testing hybrid poplar trees to see if they could be used to remediate groundwater containing TCE. APG and EPA subsequently began collaboration on a phytoremediation system for J-Field.

Methods

In 1996, a test plot of 183 hybrid poplar trees was planted to evaluate whether the VOCs in the groundwater could be naturally removed and/or destroyed by the trees or their associated microorganisms. The trees were planted 5 to 8 feet deep—almost four times the normal depth—to give the roots an opportunity to effectively filter the groundwater. The trees were arranged in a U-shaped configuration around a former disposal area. The success of the test plot led the Army and EPA to sign a Record of Decision selecting phyto-remediation as part of the remedy for the groundwater at J-Field.

By 1998, several trees had died because of the stress induced by a drought, and replacement trees were planted the following year. The replacement trees consisted of hybrid poplars, tulip trees, and silver maples—species native to APG. Using a variety of native tree species reduces the grove's susceptibility to mass wasting—an inherent weakness of monocultures. This approach is consistent with Executive Order 13112, *Invasive Species*, which directs federal agencies to restore disturbed sites with native species.

Workers prepare an area of the J-Field phytoremediation grove for the planting of additional trees.

Also during 1998, several of the original trees were excavated so that the impacts of plastic sleeves, which had been placed around the tree roots prior to planting, could be examined. It had been theorized that use of the sleeves might encourage downward root growth and groundwater uptake. However, it was found that the sleeves, coupled with the high clay content of the soil, restricted downward root growth. Lateral and surface root growth was also restricted, which caused many of the trees to blow over during a tropical storm. Based on these results, use of the sleeves was discontinued during the second round of planting. Root growth patterns were also examined, and boreholes of various diameters and depths were used in the second round of planting to encourage more extensive root growth. It was discovered that, when planting trees in tight soil formations, it is

important to score, aerate, or otherwise loosen the soils surrounding the borehole to allow for optimal root growth and development and to maximize transpiration rates.

Results

A comprehensive monitoring, sampling, and modeling program has been used to evaluate the effectiveness of the grove. Growth rates of tree roots have been monitored, and transpiration rates have been estimated to evaluate the potential rate of contaminant removal. In addition, a groundwater monitoring program has been implemented to monitor groundwater chemistry and to define the capability of the trees to provide hydraulic containment. The roots of the trees have been observed to grow up to an inch per day, and the grove has been found to absorb about 30,000 gallons of water per day during the summer growing season. The trees are functioning as a natural pump-and-treat system.

A 2002 study conducted by APG examined contaminant uptake by the trees. The detection of VOCs and their degradation products in transpiration gas, condensate, and leaf tissue indicated that the trees were removing and degrading the contaminants of concern. It was estimated that the trees had destroyed up to 60 pounds of solvents and had contributed to additional contaminant destruction by promoting biological activity in the shallow aquifer. APG estimates that site contamination may be reduced by up to 85 percent in 30 years. This natural pump-and-treat system is also reducing cleanup costs. Systems typically used to remediate such sites could cost an estimated $5 million to build and an additional $100,000 per year to operate; the phytoremediation effort is expected to cost significantly less.

In 2004, the Maryland Department of Natural Resources Forest Service presented APG with the Green Award—the highest-level award an organization can attain in the program—for the use of phytoremediation at J-Field. The award recognizes APG's successful program and sustained effort in utilizing phyto-technologies for the benefit of the environment.

Various organizations and groups—such as the APG Restoration Advisory Board, the Federal Facilities Leadership Council, foreign dignitaries, and university personnel—frequently tour APG's J-Field phytoremediation area.

Mr. Wrobel works in the Environmental Restoration and Conservation Division at APG, where he has been responsible for installationwide implementation of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) projects since 1987. He holds a bachelor's from Norwich University and a master's in engineering from the University of Lowell.

Dedication

The following members of the Engineer Regiment have been lost in the Global War on Terrorism since the last issue of *Engineer*. We dedicate this issue to them.

Sergeant First Class Joselito Villanueva	9th Engineer Battalion, 1st Cavalry Division	Fort Hood, Texas
Sergeant Michael Boatright	20th Engineer Battalion, 1st Cavalry Division	Fort Hood, Texas
Sergeant James Faulkner	20th Engineer Battalion, 1st Cavalry Division	Fort Hood, Texas
Specialist Jaime Moreno	20th Engineer Battalion, 1st Cavalry Division	Fort Hood, Texas
Captain Dennis Pintor	20th Engineer Battalion, 1st Cavalry Division	Fort Hood, Texas
Specialist Michael Wegar	20th Engineer Battalion, 1st Cavalry Division	Fort Hood, Texas
Private First Class Mark Barbet	44th Engineer Battalion	Camp Howze, Korea
Staff Sergeant Omer Hawkins	44th Engineer Battalion	Camp Howze, Korea
Private First Class Aaron Rusin	44th Engineer Battalion	Camp Howze, Korea
Specialist Oliver Unruh	44th Engineer Battalion	Camp Howze, Korea
Private First Class Andrew Ward	44th Engineer Battalion	Camp Howze, Korea
Sergeant Arthur Williams	44th Engineer Battalion	Camp Howze, Korea
Specialist David Mahlenbrock	65th Engineer Battalion, 25th Infantry Division	Schofield Barracks, Hawaii
Sergeant Charles Webb	82d Engineer Battalion, 1st Infantry Division	Bamberg, Germany
Specialist Clarence Adams	91st Engineer Battalion, 1st Cavalry Division	Fort Hood, Texas
Staff Sergeant Lance Koenig	141st Engineer Battalion	Jamestown, North Dakota
Specialist Cody Wentz	141st Engineer Battalion	Williston, North Dakota
Sergeant Catalin Dima	411th Engineer Brigade	New Windsor, New York
Staff Sergeant Michael Ottolini	579th Engineer Battalion	Petaluma, California