A MULTIDISCIPLINARY APPROACH TO INNOVATIVE TECHNOLOGY DEVELOPMENT AND DEPLOYMENT – THE INEEL TAN PROJECT

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ABSTRACT
The Idaho Universities Research Consortium through the Idaho Water Resources Research Institute conducted research on a trichloroethene (TCE) plume in a portion of the Snake River Plain Aquifer underlying the Idaho National Engineering and Environmental Laboratory (INEEL). The purpose of the research was to collect data on the biological and physical processes intrinsic to the specific area of concern and develop a model of the entire system. The data was used to determine if natural attenuation and enhanced in situ bioremediation is an effective alternative for environmental cleanup in fractured rock media. The research focused on evaluating intrinsic remediation of the plume by further understanding the hydrogeology, microbiology, and geochemistry of the fractured rock media of the Snake River Plain Aquifer. The research project was divided into three tasks. Task 1 focused on understanding the hydrogeology and microbial ecology of the aquifer system. Task 2 focused on understanding the regional geology, subsurface lithology, and geochemical characteristics of the Snake River Plain. Task 3 focused on numeric modeling of the entire system in a stochastic framework. Over forty researchers from the University of Idaho, Idaho State University, and Boise State University were involved in this integrated research effort with INEEL engineers and scientists. The interdisciplinary coverage of this research provided a bridge between pure and applied geoscience in an environmentally critical area. The data collected from these studies contributed to the successful demonstration of an enhanced in situ bioremediation process that effectively degraded TCE in the Test Area North (TAN) plume. The success of this new bioremediation process has resulted in a reversal of the preferred alternative in the TAN clean up record of decision from pump and treat in favor of this innovative technology.

INTRODUCTION
The Idaho Universities Research Consortium (IURC) was established in 1996 to facilitate an inter-university collaboration on an environmental remediation research project at the INEEL. The members of the consortium include the University of Idaho (Idaho Water Resources Research Institute, the Center for Hazardous Waste Remediation Research, and the Idaho Geological Survey), Boise State University (Center for Geological Investigations of the Shallow Subsurface), and Idaho State University. The subject of this integrated research project is a TCE plume contaminating the groundwater underlying the TAN facility of the INEEL. The purpose of the project was to characterize the intrinsic physical and biological processes that are influencing the fate and transport of the TCE plume. The data from this research was used by the United States Department of Energy (DOE) to assess whether natural attenuation and/or bioremediation is a feasible alternative for environmental clean-up of groundwater contaminants in fractured rock aquifers.

BACKGROUND

The INEEL is located in the eastern Snake River Plain, an arid closed-basin lake and basaltic plains volcanism system in the wake of the Yellowstone Hot Spot, and within the Basin and Range province. Further, the area overlies the Snake River Aquifer, one of the largest and most important bodies of subsurface fresh-water in North America.

From 1954 to 1961, the TAN facility was used to support the Aircraft Nuclear Propulsion Program. That program's mission was to test the concept of a nuclear-powered airplane. From 1962 through the 1970's, the area was devoted to the Loss-of-Fluid test facility, which was used to perform reactor safety testing and behavior studies. Beginning in 1970, the area was used to conduct research with material from the Three Mile Island reactor accident.

The principal source of groundwater contamination at the TAN site is an injection well. The injection well was used from about 1953 to 1972 to dispose liquid wastes, including raw sewage, into the Snake River Plain Aquifer. The primary contaminant of concern was the degreaser, trichloroethene. The TCE plume is nearly two miles long with a residual source area of approximately 100 feet in diameter. The contaminated aquifer is between 200 and 400 feet deep over the length of the plume.

The original remedy in the 1995 clean-up Record of Decision made in a tri-party agreement between the State of Idaho, U.S. Environmental Protection Agency, and the U.S. Department of Energy was pumping contaminated groundwater to the surface and treating it to remove the TCE. Due to the hydrogeologic characteristics of the fractured rock aquifer, projections for this pump and treat clean-up remedy were estimated to extend over 100 years in duration at a cost of over 1 billion dollars.

APPROACH

A holistic, interdisciplinary, approach was used in conducting this scientific investigation and represents a collaborative effort between university researchers and INEEL scientists and engineers. The research project was divided into three primary tasks. Task 1 focused on the hydrogeology and microbial ecology of the aquifer system. Task 2 focused on the regional geology, subsurface lithology, and geochemical characteristics opf the Snake River Plain. Task 3 focused on numeric modeling of the whole system in a stochastic framework.

Task 1 consisted of three subtasks: Hydrogeologic Analysis, Microbial Ecology and Transport Analysis, and Intrinsic Remediation Analysis. Subtask 1, hydrogeologic analysis, included the development of geophysical logs, tracer studies, borehole radara investigations, and the integration of geostatistical property definition. Subtask 2, microbial ecology and transport analysis, investigated the relationship between particle size and surface chemistry. Also, this subtask included studies of the preferred organic substrates for microorganisms in basalt aquifers through aseptic coring and processing, aerobic and anaerobic enrichments, and microbial analysis. The third subtask, intrinsic remediation analysis, investigated potential for natural attenuation and enhanced in situ bioremediation, and characterized microbes with TCE exposure.

Task 2 consisted of three subtasks: Geologic Data Synthesis of the TAN region, Geological Chracterization of the TAN region, and Geological Characterization of Surficial deposits. Subtask 1, geologic data synthesis included three-dimensional characterization in database and graphic formats and literature searches to update

reference databases. Subtask 2, geologic characterization of the TAN region included studies of subsurface basaltic rocks, studies of subsurface sedimentary interbeds, and geophysical studies. The third subtask, geological characterization of surficial deposits, included studies of surface volcanic units and studies of surface sedimentary units.

Task 3 consisted of two subtasks: Subsurface Spatial Correlation Modeling and Stochastic Groundwater Modeling. Subtask 1, subsurface spatial correlation modeling integrated geophysical data collected on TAN boreholes, imposed quantitative constraints from remote image analysis of basalt morphology, and initiated stochastic modeling of spatial distribution of high and low permeability zones for input into flow and transport models. Subtask 2, stochastic groundwater modeling, integrated work efforts with geostatistical simulation, integrated work efforts with previous INEEL models, and built hypothetical 2-D stochastic simulations of the TAN area.

RESULTS

The data collected on this project contributed to the development of an innovative in situ bioremediation technology that destroys TCE contaminating the Snake River Plain aquifer. In the Fall of 1999 through the Summer of 2000 this innovative technology was demonstrated on the most contaminated part of the TAN plume. In less than one year, under aerobic conditions, the TCE was completely degraded to its non-hazardous daughter product, ethane (Sorenson et al, 2000). As a result, this technology was deemed a potential replacement for the preferred “pump and treat” technology for that portion of the plume by the State of Idaho, Environmental Protection Agency, and the U.S. Department of Energy. In addition, groundwater samples collected at strategically placed monitoring wells have verified predictions of computer models developed on this project that TCE present in the least contaminated portion of the plume is degrading to harmless by-products through natural attenuation (U.S. DOE, 2000). Both of these innovative technologies have been presented for public approval toward modifying the original remedy to the TAN clean-up action (U.S. DOE, 2000).

CONCLUSIONS

The integrated, holistic approach utilized in this interdisciplinary research project at the INEEL can serve as a model for collaborations between university researchers and government agencies. The interdisciplinary coverage of this research provided a bridge between pure and applied science in an environmentally critical area. The information gained through this research effort is benefiting federal, state, and municipal decision-makers and will enhance environmental remediation and management solutions for groundwater contamination in fractured rock environments, nationally, and internationally.

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