Technology Demonstrations for the Installation Restoration Program

The Naval Facilities Service Center (NFESC) promotes the development of innovative remedial technology. One effective program is the Navy Pollution Abatement Ashore, Technology Demonstration/Validation Program (P2 Ashore Program) funded by the Chief of Naval Operations (CNO) and administered by the Naval Facilities Engineering Command (NAVFAC). Under this program NAVFAC's Alternative Restoration Technology Team (ARTT) identified potential sites and innovative technologies for demonstration projects. This article summarizes and highlights ongoing and completed ARTT demonstration projects.

Zero Valent Iron (ZVI) Injection Technology Demonstration

Southwestern Division and NFESC recently demonstrated the use of zero valent iron (ZVI) for removal of chlorinated hydrocarbons at Hunters Point Naval Shipyard. Objectives of the project were to determine technology treatment efficacy, cost effectiveness, injection well radius of influence, and the possibility of plume displacement.

The new technology consists of pneumatic fracturing followed by the injection of ZVI into contaminated aquifers. ZVI is a dark gray powder with an average particle size of 40 microns. Pneumatic fracturing creates pathways in the subsurface so the injected ZVI particles reach zones of contamination for treatment. Once in the contamination zone the iron particles react with chlorinated compounds creating simpler, less chlorinated compounds. The reactions continue until only safe chloride ions and water are present.

After site characterization and regulatory approval of the work plan, the project team began ZVI injection and monitoring of the demonstration. The topsoil layer is mostly artificial fill with variable hydraulic conductivity. Below the fill is weathered bedrock down to 15 feet below ground surface. Geology below 15 feet is water bearing, fractured bedrock. Depth of injection is limited only by the depth of the injection well. For this project vertical injection ranged from 7 ft to 32 ft.

A total of 16,000 lbs of ZVI was injected into four wells. Contaminants of concern were PCE, TCE, cis-1,2 DCE, vinyl chloride, chloroform, and carbon tetrachloride. TCE concentrations in the source zone exceeded 50,000 ppm. Contaminant removal was significant and ranged from 92.5 percent for chloroform to 99.4 percent for PCE.

The technology proved to be cost-effective at only $75 /cy without the need for long-term monitoring (LTM). In comparison, permeable reactive barriers are about $175/cy plus LTM, and pump/treat costs $300/cy and LTM. Dig and haul was an unacceptable remedy for this site. Injection well radius of influence was 15 feet and plume displacement during treatment was not observed.

Regulatory approval of the work plan proved to be the most significant obstacle during the project and caused a three-month delay. However, since we demonstrated ZVI injection is a viable treatment alternative, regulatory approval of future projects should be straightforward. The fall 2003 edition of RPM News has a more detailed write-up of this technology:
http://enviro.nfesc.navy.mil/erb/erb_a/outreach/newsltr/rpmnews/2003fa.pdf

For further information contact Southwest Division at (619) 532-0930 or Naval Facilities Engineering Service Center at (805) 982-1660

In-Situ Abiotic Reductive Dechlorination of Chlorinated Organics in Groundwater Using Bi-metallic Nano-Particles (BNPs)

In search of improved technology for cleanup of chlorinated aliphatic compounds, Southern Division and NFESC is demonstrating an in situ, abiotic reductive chlorination technology for the destruction and removal of TCE in groundwater. The new technique uses bi-metallic, nano-particles (BNPs) as a catalyst for reductive dechlorination.

The site for our demonstration is NAS Jacksonville, Florida (NAS JAX). The geology is silty sand on the surficial layers and sandy clay in the zone of injection. The zone of injection extends from the surficial silty sand down to 25 ft below ground surface. TCE concentrations at the site range from 1000 ppb to greater than 40,000 ppb.

Bench-scale column tests were completed in the Summer of 2003. Results from the column studies were positive with a 90 percent reduction in chlorinated compounds in only 30 minutes. Field testing is expected to begin in January 2004.

Initial results from the column tests and additional information on this technology can be obtained from Southern Division at (843) 820-5616 or from the NFESC project manager at (805) 982-1660.

Assessing the Feasibility of Applying Source Zone Treatment: Review of DNAPL Case Studies

RPMs have a limited selection of proven cleanup technologies for remediating source zones of groundwater contaminated with DNAPL. The lack of proven

treatment methods makes finding and selecting a preferred remedy difficult. To address this issue NFESC conducted a comprehensive review of DNAPL case studies to determine the efficacy of currently available source zone treatment technologies.

The process used to determine efficacy is a web-based survey, interviews with technology experts, and a review of the literature. The survey was conducted from January through April 2003 and collected information on innovative and proven technologies that have been tested or applied at DNAPL contaminated sites. Results of the survey were excellent as 128 respondents reported on the technologies being used.

Preliminary results show thermal technologies and chemical oxidation are the most often used for DNAPL source removal. Each was used in 21 percent of the cases. Bioremediation was used at 20 percent of the sites. Nine percent of the cases report source zone removal by excavation. Dual phase extraction, surfactant flushing, and zero valent iron were used to remove DNAPL sources at 10, 3, and 4 percent of the cases, respectively.

Evaluation of the sites and technologies from the survey is near completion. A final report will be available through the NFESC web site. For further information contact Naval Facilities Engineering Service Center at (805) 982-1616.

Assessing Risks to Amphibians

Engineering Field Activity Northeast worked with NFESC to develop a standardized risk assessment protocol for evaluating potential risks to amphibians at Navy installations. Wetland habitat can comprise a substantial portion of open space at many Navy facilities and it is prime habitat for amphibians. Because of the limited amount of amphibian ecotoxicity data that is available, wetland risk management decisions are often made using inappropriate species that may not be typical of the wetland. The risk assessment protocol will help the Navy avoid costly and unnecessary wetland alteration based on the use of inappropriate ecological endpoints

The team has finalized a comprehensive report and RPM guide for applying the new toxicity testing protocol for amphibians. Included are results and references from the literature search, methodologies for testing amphibians in the lab, validation techniques, a guidance manual for assessing risk to amphibians, and information from two technical papers presented in 2002. The results of this study have been used to create a web-based training tool. The web tool is available at NAVFAC's T2 web site at http://www.ert2.org/amphibians/.

For further information contact EFA Northeast by phone at (610) 595.0567 or contact Naval Facilities Engineering Service Center at (805) 982-4890.

Toxicity Identification Evaluation (TIE) to Identify Risk-Causing Contaminants-of-Concern

Engineering Field Activity North and NFESC have developed guidance and an introductory paper for use in toxicity identification evaluations (TIE). TIEs are used to identify cause and affect relationships between toxicity observed in sediment toxicity tests and factors that have contributed to the observed effects. In the guidance a new, state-of-the-art sequential extraction method is presented. The extraction method has been developed to get more accurate results that are less difficult to interpret.

While TIEs are not appropriate for all sediment sites, they are broadly applicable to a wide variety of sediment sites and data types, particularly where actionable risk is identified for acute effects on aquatic organisms. When properly executed they identify stressors that cause toxicity to aquatic life. Stressors can be risk-causing contaminants-of-concern or non-contaminant related stressors such as ammonia.

Guidance on the TIE method and the results of the case studies has been published for Navy RPMs and other end-users. The User's Guide/Summary Report (UG-2052-ENV) is available at http://enviro.nfesc.navy.mil/erb/erb_a/restoration/fcs_area/con_sed/ug-2052-tie.pdf and a RPM guide (SP-2132-ENV) can be found at http://enviro.nfesc.navy.mil/erb/erb_a/restoration/fcs_area/con_sed/sp-2132-tie.pdf. For further information contact EFA Northeast by phone at (610) 595-0567 or Naval Facilities Engineering Service Center at (805) 982-4191.

Enhanced Natural Attenuation

Southwestern Division and NFESC have developed an enhanced natural attenuation (ENA) methodology for increasing contaminant reduction rates in chlorinated groundwater plumes. We have increased attenuation rates by adding amendments such as electron donors and removing toxic by-products. The technology is considered in situ because all reactions, injections, and mixing occur below the subsurface.

The demonstration site is Moffet Field near the San Francisco Bay. The goal is to enhance already occurring natural attenuation using an injection/extraction well pair system. Sixteen (16) monitoring wells surround the contaminant reduction zone to ensure contaminants do not leave the site. Issues encountered during the project include well redevelopment, clogging of the aquifer, lengthy regulatory approval, and the use and installation of well packers. The demonstration period ended in December 2002.

Detailed project information is available in Winter edition of RPM News: http://enviro.nfesc.navy.mil/erb/erb_a/outreach/newsltr/rpmnews/2003wntr.pdf. Opportunities to implement this technology at Navy and DoD sites are very high. The ENA methodology can be implemented using existing Navy CLEAN and RAC contractors.

For further information contact Southwestern Division at (619) 532-0945 or Naval Facilities Engineering Service Center at (805) 982-1616.

In Situ Chemical Oxidation Process Using Fenton's Reagent

Southern Division and NFESC have demonstrated a cost-effective, in situ process for eliminating chlorinated and non-chlorinated organic compounds in the subsurface. The technology is known as Fenton's reagent oxidation process (FROP). It works by reacting a strong oxidizing solution with organic contaminants-of-concern such as PCE or TCE. The oxidizing chemicals can be applied in-situ by injection into the subsurface or ex-situ as in a pump/treat scenario.

The process was demonstrated in situ beginning in 1999 at NAS Pensacola in Florida for removal of the chlorinated volatile organic compound TCE. The site was a former sludge drying bed. The subsurface geology is a fine to medium quartz sand with a high hydraulic conductivity extending to a depth of 38 to 48 feet below ground surface. Shallow groundwater was encountered at the surface to four feet below ground surface. The high hydraulic conductivity greatly assisted with reagent injection and the soil's geochemistry (low bicarbonate content and low pH) are favorable for the Fenton process.

The FROP process was applied in situ into the contaminate source zone. A total of 10,127 gallons of Fenton's reagent was injected into 15 injection wells. Source zone contamination was estimated at 5,000 lbs of total chlorinated hydrocarbons. Two separate injections successfully reduced TCE in the monitoring wells from over 3,000 ppb to less than 5 ppb. The project achieved the cleanup goal of reducing TCE levels below 100 ppb.

The project objective of a massive reduction in source-zone contamination was achieved. After FROP was complete, monitored natural attenuation was implemented to reduce residual contamination. The demonstration saved NAS Pensacola an estimated $2M compared to the original remedy of pump/treat followed by long term monitoring.

The use of Fenton's reagent provides several benefits over conventional technologies. The process provides rapid, in situ reduction of contaminants to very low levels. Compared to pump/treat operations, Fenton's reagent is inexpensive and short in duration (months versus years). Additionally, process

chemical reactions provide complete destruction of organic compounds, no hazardous by-products, and no secondary waste streams.

Additional cost and performance data regarding the Fenton's process can be found at the P2 Ashore web site http://p2ashore.nfesc.navy.mil/cgi-bin/project_descriptions/cfpr_results.cfm?PROJECT_ID=128 and from the technical data sheet about the project at NFESC's environmental web site http://enviro.nfesc.navy.mil/erb/erb_a/restoration/technologies/remed/phys_chem/tds-2071-chem-ox.pdf . In March 2004, a web tool will be available from the NAVFAC T2 web site at: http://www.ert2.org/isco/. For further information contact the Naval Facilities Engineering Service Center at (805) 982-1660.

Determining Timeframes Associated with Monitored Natural Attenuation

A key question asked when evaluating monitored natural attenuation (MNA) as a cleanup remedy is: How long until natural attenuation is completed? To answer this question Southern Division and NFESC have developed software program for determining timeframes associated with MNA. The software is called natural attenuation software (NAS).

NAS estimates cleanup times through input of various site parameters. The parameters include groundwater hydrology, geochemical properties, biodegradation rates, and mass of contamination to-be attenuated (source area mass). When the parameters are input into the software and the programexecuted, the user receives (1) length of time until the contaminant plume stabilizes, (2) distance from source area at which the plume stabilizes, (3) an estimate of the overall MNA cleanup time.

NAS is quite versatile to accommodate differing site conditions. It can be used at sites where engineering removal actions have already reduced the contaminant mass in the source zone and for a number of different contaminants including chlorinated ethenes, fuel hydrocarbons, and MTBE.

For further information about the technology contact Southern Division at (843) 820-5561.