U.S. EPA TECHNICAL SUPPORT PROJECT
TECHNICAL SESSION MINUTES

July 14-17, 1998
Baltimore, MD

U.S. EPA TECHNICAL SUPPORT PROJECT CO-CHAIRS

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TUESDAY, JULY 14, 1998

WELCOME ADDRESS

The plenary session of the Technical Support Project (TSP) meeting opened with welcome addresses by Abraham Ferdas, Director of Region 3's Hazardous Site Cleanup Division, Walt Kovalick, Director of EPA's Technology Innovation Office (TIO), Jim Woolford, Director of EPA's Federal Facilities Restoration and Reuse Office (FFRRO), and Steve Luftig, Director of EPA's Office of Emergency and Remedial Response (OERR).

Abraham Ferdas

Abraham Ferdas discussed the role the Regions have in shaping the future of the Superfund program. He said that by the end of 2001, cleanup at 66% of all NPL sites will be completed. However, he does not believe that the Regions will have to decrease their number of remedial project managers (RPMs) and other technical personnel. Rather, they will need to think about how their RPMs' responsibilities will change as the program changes over time. He added that he hopes this reduction in NPL listings will make it easier for RPMs to manage their sites.

Ferdas said the States will have a larger role to play in the Superfund program of the future. Therefore, EPA needs to get involved in State activities as soon as possible. He added that the States already have an edge over EPA in dealing with voluntary cleanups and cleanups at brownfields sites. He added that EPA needs to promote the development of better equipment for the cheap and quick analysis of samples at brownfields sites.

Ferdas said that EPA needs to do a better job at accelerating the completion of cleanups at Federal Facilities and clearly defining how the Superfund process will be implemented at sites with unexploded ordnance (UXO). He then noted that EPA has become more confident in signing Records of Decision (RODs) for sites proposing ground water cleanup and natural attenuation, but more work needs to be done in these areas.

Walt Kovalick

Walt Kovalick, opened his presentation by noting that he is the designated Vice President for the Year 2000 Computer Program—a program that focuses on compliance, monitoring, and reliance on computer systems for the Year 2000. He asked all participants to remind their clients of the requirement for their systems to be Year-2000 compliant.

He then discussed the future of the remediation market, which included presentation of data on:
- funding needed to clean-up hazardous waste sites (currently estimated at $187 billion);
- primary contaminants found at hazardous waste sites (VOCs and SVOCs);
- summary of source control treatment technologies selected through FY97; and
- trends in the remediation market.

These data are available on TIO's website CLU-IN (www.clu-in.com).

Kovalick noted that 90% of sites are treating ground water contamination with pump-and-treat systems only; 5% with pump-and-treat and *in situ* treatment; and 5% with *in situ* treatment only. Air sparging is the primary technology being implemented for *in situ* treatment of ground water, but bioremediation, dual phase extraction, *in situ* oxidation, *in situ* well aeration, and passive treatment walls also are being used.

Treatment technologies for *in situ* soil remediation of metals include electrokinetics, phytoremediation, soil flushing, and solidification/stabilization. Treatment technologies for ground water include plume management, permeable reactive barriers, iron filings to dechlorinate trichloroethene (TCE), phytoremediation, bioremediation, natural attenuation, and electrokinetics.

Kovalick informed the Forums that TIO is attempting to track permeable reactive barrier technology demonstrations and applications through CLU-IN and GWRTAC. He added that phytoremediation for treating TCE in ground water also is possible and cited Carswell Air Force Base (AFB) and Aberdeen Proving Ground as sites implementing this technology.

Seventy-six RODs include statements about natural attenuation, but many do not describe the methods of implementation. Because of this, OSWER is issuing a directive in the near future on the use of natural attenuation and the importance of monitoring and site characterization before implementing it.

Kovalick said he thinks more information will become available on the use of non-indigenous organisms to degrade TCE at bioremediation sites, as well as the use of *in situ* chemical oxidation, surfactant and cosolvent flushing, and thermal vaporization and mobilization (like at Visalia) for source removal. He added that a guidance document on cost and performance data for different technologies and type should be available soon, and in November, a Federal Facilities Conference is being held to unveil guidance for new technologies. He closed with promotion of the CLU-IN and GWRTAC websites as important information tools.

Jim Woolford

Jim Woolford opened his discussion by presenting a plaque to Scott Marquess, outgoing Co-Chair of the Federal Facilities Forum, for his leadership and dedication to the advancement of the Federal Facilities Forum. He then presented information on federal facilities RODs, quality assurance and quality control (QA/QC) efforts, UXO, institutional controls, and stakeholder involvement.

Woolford noted that Federal Facilities RODs are fundamental to a successful program; however, they require greater scrutiny, especially in the area of institutional controls. Proposal plans for improving these RODs should be submitted to OERR.

Woolford then discussed an EPA Inspector General Audit that was conducted in Regions 8, 9, and 10 to see if sufficient procedures are in place to ensure the quality of laboratory data. Four specific problems were identified from this audit: QA/QC plans are not well designed; oversight of the laboratories providing data to EPA is greatly needed; EPA did not look at other Agency processes for laboratory data; and no federal system is in place to compare different Agency data. This audit resulted in the development of four recommendations:

- EPA should require QA/QC guidance.
- Increased oversight of laboratories processing data for sites is needed.
- Laboratories used by other Agencies should be assessed.
- The Executive Order to implement cleanups at Superfund sites should be modified to give EPA greater oversight capability.

OSWER's response to these recommendations was to balance EPA's QA/QC plans (including site-specific quality plans) with its own oversight and put the onus on other federal agencies to do the actual cleanups. EPA also agreed that oversight of laboratory data quality needs to be increased, DOE and DoD Quality Systems need to be assessed, and a federal system to share laboratory evaluations should be implemented.

Woolford next discussed the Inter-Governmental Data Quality Task Force, whose mission is to examine the real and perceived inconsistencies or deficiencies of new data quality systems. The goals of this Task Force are to:

1) Develop a written agreement on what is an adequate QA program.
2) Develop guidance and a framework to outline roles and responsibilities of EPA and federal facilities with regard to QA/QC oversight.
3) Develop guidance on how to implement this effort across agencies. The membership of this task force includes EPA, DoD (EDQW), NOAA, and other federal agencies.

Woolford then noted that the Range Rule is still alive and that DoD is expected to promulgate it in mid-1999. EPA has made progress in working with DoD to revise the Range Rule Risk Assessment Model protocol and FFRRO is grateful to the Regional Representatives for their work on the Range Rule team. Woolford then noted that 8,000 ranges are expected to have UXOs, but that DoD does not have a budget to address this issue at this time.

Woolford noted that institutional controls are becoming more important as more remedies requiring them are selected, but that defining institutional controls has been difficult. Issues relating to institutional controls that need immediate attention are identifying which parties will be responsible for maintenance and enforcement of them, and what kinds of institutional controls should be implemented at sites.

Woolford then discussed stakeholder involvement. He said that EPA values stakeholder involvement in the cleanup decision-making process, and that EPA has developed a "Blueprint for Action" that outlines its strategy. Anyone interested in learning more about how to promote stakeholder involvement can contact Marsha Minter (FFRRO) by phone at (202)260-6626 or by e-mail at minter.marsha@epa.gov.

FFRRO is in the process of planning its own newsletter that will include articles representing different federal facility perspectives from the Regions, States, and other federal agencies. Anyone interested in submitting an article for the newsletter should contact FFRRO. FFRRO also sponsors a website, which can be found at www.epa.gov/swerffrr/.

Steve Luftig

Steve Luftig opened his presentation by thanking the TSP Forums for their review of EPA guidance documents. He then proceeded with a discussion on Superfund issues. He said that there are fewer critics of the Superfund program and that CERCLIS, which once contained approximately 40,000 sites, only contains 10,000. He added that 5,000 removal actions have been completed under the Superfund program and that the pace of cleanup has progressed. Back in 1990, EPA cleaned only 49 sites, but in 1997, this number increased to 498.

Luftig said that by the end of next year, Superfund will have completed construction at over 700 sites and EPA is continuing to let potentially responsible parties (PRPs) take the lead. Carol Browner, EPA's Administrator, has testified that EPA is currently managing the program differently and that it is doing things faster than in the past. Congress has said it does not want the program to shut down and will continue to give EPA appropriations to fund the program.

Despite EPA's progress in cleaning-up sites, EPA wants to continue listing sites on the NPL. Last year, only 15 sites were listed. In the future, EPA hopes to list between 35-40 sites a year, despite opposition from some States. As for RCRA sites, most of them are losing money, and fewer are being led by PRPs. Therefore, there is a trend for these sites to be fund-lead sites.

In closing, Luftig said that OERR is currently working on the development of:

- guidance for five-year reviews;
- improved guidance for the completion and deletion of sites;
- RODs guidance; and
- guidance for the monitoring part of monitored natural attenuation.

PLENARY SESSION

Update on Efforts to Promote New Site Characterization Technologies and Processes

Dan Powell, TIO

Dan Powell presented an update on TIO's efforts to promote new site characterization technologies and processes through the Consortium for Site Characterization Technology. He opened his discussion with a list of evolving considerations from both the traditional and current perspective. He explained that traditionally, site characterization was accomplished through standard methods (such as Contract Laboratory Program and SW-846 methods), was expensive, took a long time, and was driven by enforcement and litigation. On-site methods only were able to accomplish screening and qualitative analysis, and off-site methods were needed for quantitative analysis. However, this approach has changed. Now on-site methods allow for both quantitative and qualitative analysis as well as screening and flexibility for performance-enhanced methods. It can be accomplished quickly and cost effectively, and end-use is the primary driver.

Site characterization traditionally has been needed at Superfund, RCRA, federal facilities, underground storage tank (UST), and State Superfund sites, but opportunities at Brownfields and Voluntary Cleanup sites are emerging to resolve contamination questions and to relieve the stigma and fears surrounding such sites. However, the goals of these two programs are different because market and future use is the ultimate objective, and cost effectiveness and fast clean-up times are needed. These programs also provide the opportunity to use innovative and field technologies.

The key hurdles to site characterization are both institutional and perception oriented. Institutionally hurdles include regulation, planning, access and credibility of available data, and procurement. Perception hurdles include the fact that many people view characterization as a study, technology is limited in its capability, there are requirements to use "approved" methods, there is more comfort with old versus new procedures, and the level of understanding is limited. To remove these hurdles, EPA needs to provide regulatory and planning guides and establish common elements in new models. EPA can influence perception by creating "better" technology information through technology verification, and promoting understanding through information products and training.

Next, Powell discussed the Environmental Technology Verification (ETV) Program. This program was developed in response to numerous reports that identified the need for environmental technology verification, the fact that many new technologies lack credibility, the inertia of systems, and the risk aversion of permitters and purchasers. The program's goal is to provide credible environmental technology performance data from disinterested third parties under the auspices of EPA.

The ETV program provides third-party verification—through Sandia National Laboratory, Oak Ridge National Laboratory, and EPA's SITE Monitoring and Measurement Program—of commercial-ready full-scale site characterization and monitoring technologies. In 1996, ETV's field work reports for cone penetrometer/laser-induced fluorescence, field-portable x-ray fluoresence, and field-portable GC/MS were completed. In 1997-

1998, field work for soil/soil gas sampling, well-head monitoring of VOCs, and PCB analysis was completed, but reports are pending.

In closing, Powell noted that from 1998-1999, ETV's efforts will include decision-support software development, ground water sampling, sediments sampling, and field extraction. ETV's future goal is to develop technology tracks, open up participation, and be fully-responsive to both vendor and user needs. These technology tracks will include:

- on-site chemical analysis;
- *in situ* monitors/analysis;
- sampling technologies;
- physical characterization;
- decision support tools;
- assessment of contaminated structures;
- toxicity testing; and
- performance monitoring.

Reactive Iron Well, Tacony Warehouse Site, Philadelphia, Pennsylviania

Mark Sylvester, Radian Corporation

Mark Sylvester described a treatment system designed to treat a ground-water plume containing tetrachloroethene (PCE) and TCE at the Tacony Warehouse in Philadelphia, Pennsylvania. He explained that the contaminated water table aquifer underlying the site is silty and about 25-feet thick. The hydraulic conductivity of the aquifer is 1.1×10^{-4} - 1.4×10^{-3} cm/s, and the hydraulic gradient is 0.002.

The treatment system consisted of four 35-foot deep extraction wells constructed with iron treatment cells to dechlorinate the PCE and TCE. A 54-inch diameter borehole telescoped to 48-inches was drilled for each well. The annulus around each 4-inch diameter well was backfilled with iron filings mixed with a soil amendment. Each was pumped at 1¼ gpm and had a 33-foot radius of influence. The residence time of the treatment cells was 7-8 hours, which can be reduced by increasing the pumping rates.

The well installed near the presumed source reduced PCE and TCE concentrations from 2,000 µg/L and 200 µg/L (measured in a piezometer adjacent to the well), respectively, to below detection limits. The concentrations from the treatment cells increased a bit over time. This may be attributable to break-through that may occur if the recharge capacity of the iron filings was reached.

Questions and Answers

Question: How does the cost of the iron treatment cell compare with installing a permeable reactive barrier?

Answer: The site would have required a 500-600 foot long and 40-foot deep excavation for installation of a barrier. This would have been very expensive ($4-5/ft^3) to excavate and fill with iron filings. Caisson rigs for drilling the treatment cells are widely available and quick.

Question: Were the wells drilled to bedrock?

Answer: Weathered rock was encountered, but not competent bedrock.

Question: Can the residence time be increased to further decrease concentrations?

Answer: Yes.

Question: What are the economic reasons for placing the treatment cells in the wells rather than above ground?

Answer: Placing the cells below ground makes it easier to control the dissolved oxygen. If the cells were above ground, nitrogen would be added to prevent the iron filings from rusting. Also, the potential for vandalism and theft at the Philadelphia site was minimized by placing the treatment system underground.

Question: What were the beginning and ending concentrations?

Answer: The highest measured concentration was 4,000 µg/L of PCE. The concentrations of PCE and TCE in the effluent were <5 µg/L. The concentration of *cis*-1,2-DCE and vinyl chloride, which may have resulted from degradation processes, was 100 µg/L. The concentrations of dissolved iron in the effluent were at the detection limit and were not a problem.

Further questions on the Tacony Warehouse site may be directed to Russell Marsh (CENAB-EN-HT) at (401)962-2227.

Update on Remediation Technology Development Forum

Kathleen Yager (TIO)

Kathleen Yager presented an update on the Remediation Technology Development Forum (RTDF). She explained that the RTDF is a consortium of partners from industry, government (co-chaired by TIO and the National Risk Management Research Laboratory) and academia. Its goals are to develop more effective, less costly technologies, identify priority needs, and perform collaborative projects. Its approach is to conduct research, perform technology assessment, prepare technical guidance documents, and facilitate regulatory acceptance. It has a website at www.rtdf.org.

Yager noted that she wanted to get feedback from the Forum on whether the RTDF is properly representing EPA's interests, as well as to determine whether the RTDF has room for more Forum involvement.

The RTDF is made up of the following seven "Action Teams:"

- Bioremediation Consortium;
- Permeable Reactive Barriers;
- Phytoremediation;
- *In Situ* Flushing;
- Sediments;
- IINERT; and
- Lasagna.™

<u>The Bioremediation Consortium</u> is co-chaired by Greg Sayles (EPA/ORD) and Dave Ellis (DuPont). It consists of three workgroups: Intrinsic Biodegradation, Accelerated Biodegradation, and Cometabolic Bioventing. Its team goals are working to accelerate the development of *in situ* technologies; achieve regulatory acceptance; and develop guidelines for use at other sites.

The Intrinsic Biodegradation Workgroup is working on a two-phase process. Phase I consists of the following:

- evaluating the importance of natural attenuation for chlorinated solvents;
- developing an understanding of mechanisms, predictive models, and protocols; and
- promoting public and regulatory acceptance.

Phase II is just getting underway and will include:

- further understanding of mechanisms;

- applications of predictive models; and
- understanding of natural attenuation sources and best monitoring practices.

The Accelerated Biodegradation Workgroup also is working in two phases. Phase I involves a field demonstration at Dover AFB to clean up chlorinated solvents. The approach applies electron donors, electron acceptors, and nutrients to the subsurface, together with cultured microbes from Pinellas, Florida. The design includes three injection and three extraction wells in a hydraulically-controlled system where supplements are added to the subsurface and recycled back through the test area. Results show that prior to bioaugmentation, dehalogenation stopped at DCE, but after bioaugmentation, there was complete dehalogenation to ethene. Results are published in an *ES&T* article. Phase II includes a full-scale implementation project at Dover AFB as well as a possible second demonstration site for the technology.

The Cometabolic Bioventing Workgroup is conducting a field study at Dover AFB that will add propane and air to the vadose zone. A field study at Hill AFB also is being designed.

<u>The Permeable Reactive Barriers (PRB) Workgroup</u> is being co-chaired by Bob Puls (SPRD-Ada) and John Vidumsky (DuPont). Its workgroups comprise of chlorinated solvents, inorganics, and radiological contaminants. Its team goals are to:

- Develop reactions that occur in walls.
- Demonstrate and validate effectiveness.
- Develop effective emplacement techniques.
- Develop protocols, guidance, and issue papers.
- Perform economic analysis of treatment.

This workgroup is currently in the process of putting PRB project profiles on RTDF's website. These profiles include short summaries of 30 sites, including descriptions of the sites, wall design, target contaminants, performance efficiency, and installation and O&M costs. These profiles will be updated every 6 months. This workgroup is also tracking long-term performance of the technology over a 3-year period to evaluate the integrity of six walls and develop improved methods for monitoring. The workgroup also plans to provide training to federal and state regulators in early 1999 on how to install and monitor PRBs.

<u>The Phytoremediation Workgroup</u> is being chaired by Steve Rock (ORD) and Lucinda Jackson (Chevron). Its workgroups include Total Petroleum Hydrocarbons (TPH), TCE, and Vegetative Caps. The Team's goals are to:

- Assess the status of research.
- Identify key research gaps.
- Facilitate validation of the technology.
- Determine appropriate uses.

The TPH Workgroup has developed a field study protocol, which will include guidance on plot size, soil sampling, microbial sampling, and statistical analysis. The TCE Workgroup is in the early stages of developing a field study protocol similar to the TPH protocol. The PCE Workgroup is conducting field research at dry cleaning sites and a project to identify additional plant species. The Vegetative Caps Workgroup is developing a monitoring protocol, which is currently in draft form.

<u>The *In Situ* Workgroup</u> is being chaired by Lynn Wood (EPA/ORD) and Steve Shoemaker (DuPont). Its five workgroups are:

- Technical Practices/Protocol;
- Economic Assessment;
- Surfactant Recovery/Re-Use;
- Endpoint Assessment; and

- Full-Scale Design.

Currently, the workgroup is developing a technical practices manual that will address design and technology needs.

The Sediments Workgroup is being co-chaired by Denis Timberlake (EPA/ORD) and Richard Jensen (DuPont). Its four workgroups are:
- Risk Assessment;
- *In situ* containment/capping;
- *In situ* treatment; and
- Natural recovery.

This workgroup is planning to meet again in September to discuss the projects they would like to work on.

Yager noted that the RTDF will continue to track its progress and that updates will be provided on future Forum conference calls. In addition, all Forum members will be put on the RTDF mailing list for receipt of all RTDF updates. She added that the TSP may be approached for participating in the RTDF's review process, as well as for participating in semi-annual and annual meetings.

Problems with Extraction and Injection Wells (Emphasizing Biofouling)

Stephen White, U.S. Army Corps of Engineers (USACE)

Stephen White provided an overview of the problems that may be encountered with extraction and injection wells used for ground-water treatment. He explained that declining extraction well performance results in less water sent to treatment plans. Often an attempt is made to improve well performance with an *ad hoc* solution such as adding hydrochloric acid to the well. When the *ad hoc* solution fails, the treatment plant shuts down, and the parties involved seek to place blame for the failure. It may take weeks or months to develop an appropriate solution, but in the meantime, the extraction wells degrade.

Extraction well problems can result from incomplete site characterization, because a poor understanding of the site geology, hydrogeology, geochemistry, and microbiology can lead to poor placement and design of wells. Problems may also result from poor well installation or development procedures. These problems can be avoided by being specific in the scope of work; providing 100% technical oversight by qualified personnel during installation and development; pre-developing all wells; conducting a video camera survey of all wells; and beginning preventative maintenance immediately. White pointed out that procedures for installing extraction wells are not the same as supply wells due to lower pumping rates, the presence of contaminants, and the position of the pump (within the screened interval, not above).

Other issues that should be considered in construction of extraction wells include surface completion, vaults, and transport lines:

Surface completion:

- incorrect pumps (wiring, seals);
- incompatible materials;
- access and layout problems;
- confined space limitations;
- unable to insert probes or instruments;
- unable to sample wells; and
- unable to isolate wells.

Vaults:

- above ground vs. below grade;
- controls, flow meters, *etc.*;
- accessibility for operation and maintenance and sampling;
- drop tubes;
- confined space; and
- explosive hazards.

Transport lines:

- install cleanouts;
- low point crossovers;
- sediment accumulation;
- substrate for biofouling;
- jetting or pigging.

Injection wells differ from extraction wells in that 1½ injection wells are needed for every extraction well. They have greater clogging potential and different development protocol. Furthermore, an injection step test must be conducted on injection wells to determine the specific capacity of the wells.

Clogging of injection wells can be caused by suspended particles, gas bubbles, bacterial infestation, chemical precipitation in water, chemical reactions in the soil, swelling and dispersion of clay, and hydrofracturing. There are several injection well design issues to consider to prevent clogging such as excess capacity, alternate disposal options, compatibility of effluent chemistry with aquifer geochemistry, minimizing aeration by using a drop pipe, and performing an injection step test.

An O&M plan for the treatment system should be written by the designer because the designer has qualified staff and faces no economic disincentives. Without an O&M plan, wells are often ignored once the system is balanced. Well performance may decline due to biofouling, which is caused by a consortia of bacteria that forms on a substrate in the filter pack of the well and the surrounding formation. The substrate traps particulates and causes the formation of chemical precipitates—particularly iron and manganese.

There are several rehabilitation strategies for wells impacted by biofouling including addition of acid, heat, ozone, or liquid carbon dioxide. In addition, the wells can be redeveloped, or blended chemical heat treatment can be applied. Blended chemical heat treatment involves a shock phase, disruption phase, and dispersion phase. During the shock phase, microorganisms are physiologically shocked to soften the biomass, enhance penetration of heat and chemicals, and reduce the chemical demand during the disruption phase. There are two means of shocking the microorganisms: chemical and physical. These involve:

Chemical:

- acetic or hydroxyacetic acid;
- sulfamic acid;
- wetting agent;
- pH 1.2-1.6; and
- five times the casing volume.

Physical:

- jetting at 10 gpm;
- vertical feed rate < 1 ft/s;
- temperature 200°F at nozzle; and
- after 30 minutes temp.= 170°F, and pH=2.

During the disruption phase that follows, the application of heat softens the biomass; acids dissolve the chemical encrustants and biochemical deposits; wetting agents suspend clay, iron, *etc.*; and agitation breaks up the biomass and encrustants. Implementation of the dispersion phase is typically started 2 feet off the bottom of the well, and the well is treated in 5-foot increments. After 30 minutes in this phase, the temperature reaches 180°F, and the pH is less than 2. During the dispersion phase, the wells are surged the next day using an open surge block to break up the biomass. Well development is conducted until the well yield is comparable to the original yield.

White provided tips for pump preventative maintenance and well redevelopment. He indicated that well rehabilitation costs depend on screen length, well diameter, and the costs for mobilization and demobilization. It typically takes 6-8 days to rehabilitate a group of three wells at a cost of $5,000-15,000 per well. Intangible shutdown costs are also incurred. Poor preventative maintenance can eventually lead to the shutdown of the treatment plant, and a loss of customer's confidence and the regulator's good will. Tens of labor days are lost, and contractors may file damage claims.

In conclusion, to prevent a decline in well performance:

- O&M is required for the treatment plants and wells;
- preventative maintenance needs to be programmed into the design of the system;
- O&M plan for wells should start on Day 1; and
- the shakedown period should be lengthened.

Failure to carry out preventative maintenance will lead to plant shutdown, and failure to clear preventative maintenance procedures with the regulators will severely complicate subsequent well rehabilitation. System performance should be monitored and preventative maintenance should be easy to implement.

White expects to have a draft-final copy of guidance dealing with extraction and injection wells soon. He is also hoping to develop an O&M program for extraction wells. He encouraged the meeting participants to contact him by e-mail (stephen.j.white@usace.army.mil) if they have any questions.

WEDNESDAY, JULY 15, 1998

SOIL VAPOR EXTRACTION MODULE

David Becker, USACE-Omaha District

David Becker delivered a workshop module entitled "Determining Optimization and Closure at SVE Sites." The workshop covered:

- basic principles of soil vapor extraction (SVE) projects;
- good design practice (including site characterization, subsurface design, and equipment);
- SVE optimization (including definitions, data requirements, extraction operation changes, and equipment optimization); and
- SVE site closure (including approaches and modeling).

A complete set of course materials was distributed to Federal Facility Forum participants. For further information on the module, please contact a Regional Forum representative or David Becker at (402)2667-2655 or dave.j.becker@usace.army.mil.

UXO WORKGROUP MEETING

Multi-Sensor Towed Array Detection System

Jim McDonaldson (Naval Research Laboratory)

Jim McDonaldson presented information on the Multi-Sensor Towed Array Detection System, otherwise known as MTADs. The MTADs was developed to assist both military and civilian organizations in UXO site characterization. According to McDonaldson, MTADs represents the state-of-the-art in UXO detection, localization, and discrimination. It addresses each of the substantial shortcomings of hand-held magnetic survey systems.

The MTADs incorporates both cesium vapor full-field magnetometers and active pulsed induction sensors. The sensors are mounted as linear arrays on low-signature platforms that are towed by a customized all-terrain vehicle. The position-over-ground is plotted using advanced Differential Global Positioning Systems (DGPS) technology that also provides survey planning and vehicle guidance during surveys. As a towed platform, the MTADs is capable of surveying 10-25 acres per day depending upon terrain. The DGPS provides positional accuracies of about 10 cm. With ordnance detection efficiencies in excess of 95%, survey costs per acre and per target detected are significantly less than for hand-held surveys conducted on sites larger than a few acres.

Over the last two years, the MTADs has completed a series of technology demonstrations at both prepared test ranges and live sites. These include National Research Laboratory's Chesapeake Bay Detachment; the Marine Corps Air Ground Combat Center at Twenty-Nine Palms, California; the Jefferson Proving Ground in Madison, Indiana; the Badlands Bombing Range, South Dakota; and the former Ft. Pierce Amphibious Base, in Ft. Pierce, Florida.

UXO Clearance and Demining Quality Assurance

Norrell Lantzer, Comarco Systems, Inc.

Norrell Lantzer discussed his company's use of QA to determine the success of its clients' UXO demining efforts. He explained that his company works with its clients to ensure the efficacy of its client's contractor quality systems, planning, resource allocation, staffing (for required skills), and training. In addition, his company assesses performance and verifies results of UXO demining efforts. He then discussed Comarco's integrated approach to QA for the planning, in-process, and post-clearance stages of a UXO demining effort.

Stan Zawistowski (Region 8) said that he thinks that more work needs to be done on the discovery phase of UXO demining efforts and that archival data should be carefully documented. He added that he thinks many UXO sites should be declassified and that the information for these sites should be made available to the stakeholders involved. Harry Craig (Region 10) said that documented interviews with nearby neighbors to these sites needs to be part of the archival search reports. Zawistowski added that the quality of existing archival reports is inconsistent and that many people do not rely on them when engaging in demining efforts. Craig then noted that poor-quality archival reports lead to an insecurity about whether the necessary information has been collected, but that EPA is still being pressured to move cleanups at these sites forward.

Doug Bell (FFRRO) said that detection methods that produce false negatives and unknowns are a real problem and wondered how bound the USACE and other federal agencies are to the DDES Board's recommendations. Lantzer said that in the process of QA, good site documentation is critical; otherwise QA reports will need to be redeveloped in five years.

Lantzer said that spider diagrams can be used to assess the condition of a site to determine risk. He added that site investigations should include documentation of frost environments, erosion patterns, and pushed uplands to determine risk.

Carol Witt-Smith (Region 5) asked whether any QA procedures should be implemented to find UXO in trees and whether each tree should be examined. Lantzer said it depends on the future land use for the site. For example, if the land is going to be logged for timber, every tree needs to be examined individually.

Craig said that removals are being conducted more frequently than needed at UXO sites because EPA is being pressured to verify that these sites are clean. He added that he is not seeing QA being implemented in the field at federal facility sites 90% of the time.

General Discussion

The workgroup briefly discussed the presentations summarized above. Most noted that both discussions were useful, but the presenters went a little fast and some of the information, especially about data collection methods, contradicted what many workgroup members believe. Bell added that the false positive issue needs to be discussed further.

The workgroup then discussed a draft of the "RCRA ARARS for Range Clearance and OB/OD of UXO at the Badlands Bombing Range, South Dakota" paper, which will be discussed at the stakeholders meeting on August 25, 1998. The purpose of the document is to provide guidance regarding RCRA ARARS for range clearance and on-range OB/OD of UXO at closed or transferred ranges, based on RCRA corrective action and §7003 authorities and 40 CFR 264 Subpart X, which contains the RCRA standards for OB/OD. It was noted that the workgroup hopes the paper will encourage the military to buy into EPA's proposed process for the Badlands site and, ultimately, serve as a National Position Paper on all cleanups.

Zawistowski expressed his concern that some USACE contractors are conducting faulty preliminary assessments that do not meet the assessment protocol of EPA and that they are not properly reporting releases at their site. He added that the EPA preamble says information on sites should be reported in CERCLIS, but some contractors are reporting such information in USACE's DESSERT database instead.

Craig noted that EPA's Hazardous Ranking System (HRS) is not designed for ranges, making it difficult to get ranges listed on the NPL. Bell said FFRRO is discussing changing the parameters used for the HRS so that ranges will qualify for listing on the NPL.

Zawistowski noted that some federal facilities try to get around EPA's Off-Site Rule by immediately beginning a removal action after completion of their preliminary assessment and site investigation. This way, no additional data can be collected to determine whether the site needs to follow the Off-Site Rule.

A workgroup member noted that DoD has been misinterpreting EPA's proposed RCRA "sunset" provision, so this provision has been postponed for the time being. Instead, RCRA Corrective Action and 7003 authorities will apply and RCRA permits will be required for exhumed materials. Bell said this helps define the direction of the Range Rule.

SITE CHARACTERIZATION FOR THE 21ST CENTURY

The Field Use of the Automated Sampling and Analytical Platform: What Worked, What Didn't, and at What Cost

Gary Hopkins, Stanford University

Gary Hopkins described the use of the automated sampling and analytical platform (ASAP) at two sites in California: Edwards AFB and the Weapons Support Facility at Seal Beach. The ASAP consists of a purge-and-trap GC unit, a high-pressure liquid chromatography (HPLC) unit, and sampling probes (sulfide and pH) and serves as an interface between monitoring wells and analyzers. The purge-and-trap unit is designed for volatile organic compounds (VOCs) with loops ranging from 200 μL to 10 mL. The ASAP also is equipped with a computer for data analysis.

Co-metabolic degradation is being used to treat TCE contamination at Edwards AFB by adding toluene to the subsurface via two treatment wells. Twenty-eight monitoring wells were installed with 39 ASAP sampling points. The monitoring wells were equipped with Rediflo-2 Grundfos pumps at a depth of 30 feet below ground surface (bgs).The ASAP used at Edwards AFB is equipped with a photoionization detector followed by a flame ionization detector in series. It operated in a wide range of concentrations.

Anaerobic biodegradation is being used to treat contamination at Seal Beach, and about 30 compounds are being tracked. Each well at the site has a total of seven individual sampling lines for a total of 105 sampling points. The depth to ground water is 7 feet bgs.

Hopkins summarized the results of sampling at each site and described the successes and problems with the application of ASAP. He followed up with the costs of constructing and operating the ASAP. The gas chromatograph and ion chromatograph cost $64,775 and $40,500, respectively. The monthly operating costs of the instruments are $1,480 and $1,195, respectively, assuming 25 samples are analyzed daily. The sampling probes cost a total of $6,610 with a monthly operational cost of $970.

At Edwards AFB, the sample manifold—28 Grundfos pumps and 28 ¼-inch ports—cost $58,350. It cost $3,025 per month to operate, again assuming 25 samples per day. The pumps need to be replaced approximately every month. At Seal Beach, the sample manifold—105 ⅛ -inch ports—cost $45,000. It cost $60 per month to operate. Overall, it cost $167,950 in system costs and $7,875 per month in operational costs (including 3 hours per day of data validation) to analyze the samples at Edwards AFB ($12.60 to $15.30 per sample). At Seal Beach, system costs were $155,875 and operational costs were $9.75 to $12.20 per sample.

Questions and Answers:

Question: How do you deal with sediment in the sample line?

Answer: There is a glass wool filter at the end of each sample line. The wells are surged until the sample lines run clear, which occurs quickly.

Question: What are the sample run times?

Answer: Most samples analyzed by GC take about 40 minutes.

Question: How is the investigation-derived waste handled?

Answer: The collection of a sample generates about 50 gallons of water. The water is pumped to a tank, filtered, and returned to the treatment wells.

Question: Didn’t the redox of the treated water change before it was returned to the treatment wells?

Answer: The electron-acceptors are removed before reinjection.

Question: Can the ASAP be used throughout the monitoring life of the site, for example, 20 years?

Answer: Yes. The ASAP is more appropriate for long-term use because the set-up costs are too expensive to use in the short term.

Uses of Vapor Diffusion Samplers to Detect VOCs at the Ground Water/Surface Water Interface Near Superfund Sites in New England

Forest Lyford, USGS

Forest Lyford described vapor diffusion samplers and provided examples of their use at several sites. He noted that vapor diffusion samplers are very simple devices that can be used during remedial investigations to identify the location and width of VOC ground-water plumes as they enter streams. They also can give relative concentrations of VOCs along the width of the plume.

The vapor diffusion sampler was described by Don Vroblesky in the journal *Ground Water*. It can be easily and quickly assembled in the field by inserting an uncapped 40-mL VOA vial into a plastic sandwich bag and expelling as much air from the bag as possible. The sandwich bag should be stretched over the vial opening and secured with two or three cable ties. (Tape should not be used because it can introduce toluene into the sample.) The assembly is then placed inside a second plastic bag and attached to a pin flag so it can be located easily when placed in a stream bed. Approximately 15-20 samplers can be assembled in one hour.

The amount of time to install the sampler in the stream bed (or lake bed or wetlands) depends on site conditions. At the Baird and McGuire Superfund site in Massachusetts, 180 samplers were installed in one day. Installation was facilitated by optimum conditions—shallow water and no brush.

The samplers typically are installed to a depth of 6-8 inches in the stream bed, although depths may be varied to assess the changes in concentrations with depth. The samplers are allowed to stay in place for approximately two weeks until the VOCs in the water reach equilibrium with VOCs inside the vial. They are then extracted from the stream bed, and the outer bag is removed to get rid of the coating of grime. The vial is capped and taken to a field gas chromatograph for analysis.

The Vroblesky article recommends using a bucket auger to dig the holes in the stream bed; however, this method is impractical for the gravel-bed streams of New England, so a shovel can be used instead. In deeper water, a drive point can be used to install samplers. At the Baird and McGuire site, a 2-inch diameter pipe was used to advance a hole into the sediments, and the sampler was emplaced with an inner 1¼-inch diameter pipe. PVC pipes can be used in fine-grained stream beds, but steel pipes are needed for coarser sediments.

Passive diffusion samplers were used at the Eastern Surplus Superfund site in Meddybemps, Maine, to help delineate a ground-water plume at the ground water/surface water interface. The passive diffusion results confirmed the data observed in monitoring wells, but also helped identify the location of a previously unknown ground-water plume.

At the McKin site in Gray, Maine, the width of a VOC plume was mapped along a stream and was found to extend further downstream than previously expected—the plume was actually passing under the river and discharging further downstream. VOCs were detected in samplers placed on both sides of the banks and in the center of the stream, but the side of the stream receiving the plume had the highest concentrations. The highest concentration measured was 30,000 ppb.

Passive diffusion samplers also were installed in a pond on Cape Cod, both parallel and perpendicular to the shoreline. Off-shore points were needed because of the depth of the ground-water plumes, and their installation was performed by a diver from the Woods Hole Oceanographic Institute. PCE and TCE plumes were present at different levels in the aquifer, so different discharge points for the two VOCs were observed.

At the Baird and McGuire site, it was suspected that VOCs were still discharging to the stream even though bottom sediments were remediated and a ground-water treatment system was implemented. A total of 240 samplers were installed along the stream banks and centerline. The results showed that VOCs were present in the bottom sediments, and high concentrations were observed in the areas where there were high concentrations in the plume. Stream conditions were monitored while the ground-water treatment system was operating and when it was shut down. The highest concentrations were observed when the system was shut down. In addition, a previously undocumented TCE plume was located downstream based on the results of passive sampling.

Finally, passive samplers used near a landfill at the Naval Construction Battalion Center in Rhode Island helped to identify the possible position of the plume source. Results also suggested that the plume was not discharging to a nearby wetland.

Questions and Answers

Question: Were samples stored together and were trip blanks used to assess possible transfer of VOCs between samples during transport? I have found low levels of VOCs in trip blanks that were likely the result of transfer. (20-30 samples were stored together in a refrigerator while awaiting analysis.)

Answer: One or two samples were retrieved at a time and capped right away. Trip blanks were not analyzed because once the vials are capped, there is little opportunity to transfer contaminants. However, QA/QC protocols probably should be practiced. Duplicate samples have shown comparable results, although a lag time in capping the samples can affect the results.

Question: Did you try to correlate results to the differences of the sediments in which the samplers were buried?

Answer: Sediment descriptions were recorded, but no obvious patterns have been observed yet. At the McKin site, the bottom sediments ranged from clay to gravel.

Beyond the Water Well: A New Multi-Level Sampling Technique

Carl Keller, Flexible Liner Underground Technologies, Ltd.

Carl Keller presented the FLUTe method, a multi-level sampling technique that uses everting liners. He designed the system when challenged to develop a technique to validate models. Keller began his presentation by summarizing the common water sampling methods, which include water wells, straddle packers, and direct push technologies. Factors to consider when selecting a method include:

- initial cost
- vertical resolution (sample spacing)
- impact on sample quality
- water table measurement capability
- ease of procedure
- vertical seal quality (especially in ragged holes
- depth capability
- volume of sample available
- hole stability
- low-flow medium capability
- lifetime of system
- removable capability and cost
- compatibility with logging tools
- horizontal emplacement capability
- adjustability of sampling elevations at the site
- reusability
- purge quality on emplacement
- emplacement in domestic wells

The FLUTe method differs from common sampling methods in that there is a good hole purge upon installing the apparatus and a small purge when sampling. The effect of sample pumping is minimal. The apparatus fits in many hole sizes and shapes—even horizontal holes. It seals the entire hole and has a higher spatial resolution in a given hole diameter. The FLUTe apparatus is easily removed and reused and is compatible with simultaneous logging methods. Measurements of conductivity and permeability are easy. Well effects are avoided because samples are collected right from the medium with no well completion materials installed.

The everting liners usually consist of a coated nylon fabric with a tether attached. The liner is placed in the well and filled with water so that the water level in the liner is higher than the static water level. The liner does not slide down the hole; rather, it everts as it descends the hole. The rate of descent is controlled with a purge pump, which purges the hole during installation. As the liner descends, it does not touch the walls of the borehole until the hole is stabilized. The water-filled liner seals around the purge pump hose. Spacers located on the outside of the liner and at each sampling interval provide an annulus between the liner and the borehole wall.

It is common to have 5-10 sampling ports in one hole, but as many as 17 ports have been installed. Each sample tube needs a bladder pump to collect water samples, and bladder pumps are expensive. As a result, a new pumping system was designed that is simpler, better, and less expensive. The pump consists of a U-shaped tube, which is filled with water. One end is depressed to the elevation of the sampling port, and the sample water is displaced and flows to the surface from the other end of the tube. In one or two strokes of the pump, the water can be purged. The permeability of the aquifer can be deduced from the flow rates obtained.

The sampling process is relatively quick. At a site in Pennsylvania, Keller was able to withdraw 40 samples per hour. A sample analysis system can also be placed at the end of the ports to obtain immediate results.

The seal provided by the everting tubes is better than that of straddle packers because the hole is continuously packed off. Everting tubes are easy to emplace in many situations such as:

- partially cased holes (domestic wells);
- horizontally (*e.g.*, beneath landfills);
- inside sonic casings (in hard to drill media); and
- in sealed holes (holes already sealed by a blank liner).

Field applications of the FLUTe system are growing. There is a very large experience base with miles of liners in the vadose zone in Western sites. The new sampling design was tested in Pennsylvania in September 1997, and blank liners were installed at a site in New Jersey in July 1998. Six wells will soon be installed in Valley Forge, Pennsylvania.

The objectives of the FLUTe design are to:

- reduce the effect of the hole by eliminating the open volume and sealing the entire hole;
- draw samples directly out of the medium;
- use tubing large enough to allow flow measurements;
- reduce the time and equipment needs for installation (including drilling costs);
- allow high spatial resolution; and
- allow measurements in fractured and karst formations.

In the future, the system will be installed in mud-filled holes, holes with a first sealing liner, and horizontal holes while they are being drilled. It also will be used to sample both the saturated and vadose zones. At the Westinghouse Savannah River Site, the method was modified so that a tyvek-coated ribbon treated with Sudan IV (a color reactive material) could be lowered with the everting tubes into holes that were advanced by a cone penetrometer rig. The hole was advanced to 100 feet below ground surface, ground water was sampled from 10 ports, and the ribbon was removed, all within two hours. The red blotches on the ribbon corresponded to where TCE dense non-aqueous phase liquid (DNAPL) had pooled above a clay layer.

<u>Questions and Answers</u>

Question: How much does it cost to install the FLUTe system?

Answer: The cost is about $40 per linear foot for holes with 10 sampling ports. This includes the cost of the liner ($14/foot) and the costs of parts. Installation is relatively quick and is easier in larger diameter holes. The cost of the Sudan IV-treated ribbon is about $5 per linear foot.

Molecular Approaches for Characterization of Microbiological and Biogeochemical Heterogeneity at Contaminated Sites

Sheridan Haack, USGS, Lansing, Michigan

Sheridan Haack described a new method for evaluating microbial activity, plume dynamics, and site heterogeneity. The new method is under development and is based on DNA extraction methods. It has potential for use in determining the location of microbiological reactions, the location of unique biogeochemical environments, where to sample for microorganisms, and temporal variability in microbial processes. DNA analysis can be conducted to compare the similarity of community nucleic acids in separate samples, determine whether a specific functional gene (for example, toluene degradation genes) is present in the bacterial population, and determine which bacteria are active in the sample.

A major advantage of the new method is that DNA is extracted directly from environmental samples, not from traditional cultures. With traditional culturing, the bacteria that successfully grow in an artificial medium may not represent the species that contribute to important degradation processes *in situ*. In addition, the process is time-consuming and only a small percentage of bacteria will survive in the laboratory. The new DNA-based method evaluates the entire *in situ* population of bacteria. Also, the new method does not take as much time as culturing, so more samples can be analyzed in the same amount of time.

The new method has been applied at the Wurtsmith AFB in Oscoda, Michigan, to characterize microbiological heterogeneity and relate biodegradation reactions to physical conditions. The site is located three miles from

Lake Huron. The water table is 18 feet below ground surface, but varies by 2 feet over the year. A plume from Fire Training Area 2 is contaminated with low concentrations of fuel and chlorinated solvents. Most of the contaminants are sorbed to aquifer solids within the zone over which the water table varies. Parts of Geoprobe cores (to depths of 12 meters) taken in October 1995, June 1996, and October 1996 were analyzed using the DNA methods

The objective was to find correlations among four parameters—terminal electron accepting processes (TEAPs), geochemical conditions, bacterial communities, and bacterial populations. TEAPs were determined using concentrations of hydrogen gas formed as the result of microbial activity. This analysis located zones of methane, sulfur, and iron reduction. Outside of these zones, the ground water was aerobic. Community profiles were created by replicating 16rDNA and cutting the DNA strands into smaller pieces using enzymes. The cut pieces form banding patterns on a gel that are specific to a particular bacterial community. The banding patterns from analyzed samples were scanned, digitized, and compared. Cluster analyses were performed to group similar communities. Further analysis found correlations between clusters of similar bacterial communities and contaminants, pH, and specific conductance. The distribution of bacterial populations was evaluated using RNA hybridization techniques. Labeled probes were made to detect and quantify specific functions, such as sulfate reduction and methanogenesis.

Bacterial functions were found to vary over small scales. Improved information on the spatial and temporal variations of bacterial functions can be used to make more accurate models and improve predictions of biodegradation rates.

Questions and Answers

Question: How transient are bacterial populations?

Answer: Methanogenic populations definitely changed over a period of six months. Although populations do not go away, they will cease to perform certain functions.

The Use of Rapid Adaptive Site Characterization for Understanding the Anatomy and Processes of Contaminant Plumes

Seth Pitkin, Stone Environmental, Inc.

Seth Pitkin described the use of Rapid Adaptive Site Characterization (RASC) to characterize a plume. It is an in-field profiling technique involving an iterative feedback and response cycle to refine the conceptual model as work proceeds. RASC emphasizes determining the scale of heterogeneity and characterizing source areas and internal plume anatomy. Implementation of RASC requires development of a detailed conceptual model and senior scientists in the field to perform the work.

RASC is a minimally invasive technique that produces near real-time data with rapid on-site turnaround. The technique provides vertical profiles of concentrations, hydraulic conductivity (relative, not absolute values), head, and physio-chemical parameters. Ground-water samples can be analyzed for on site in five minutes using solid phase microextraction. The data can be graphed by the time the hole is completed, and the results are comparable to those obtained with standard GC/MS techniques.

The Waterloo Profiler used in RASC is a simple tube penetrometer that can be driven into the subsurface with a Mobile B-57 drill rig. A potentiometer hooked to the profiler monitors the drive depth. Data can be viewed on a laptop computer as the profiler is advanced. Advancement of the profiler can be stopped to collect a ground-water sample. When the profiler is stopped, temperature, conductance, pH, redox, and water level are measured. The sampling ports of the profiler empty into an ⅛-inch tube in an AW rod, and the annulus of the AW rod is filled with grout. A nitrogen gas drive pump can be used to obtain samples at greater depths.

The profiler was used at a site in Massachusetts where PCE concentrations were high near the source area, which was in a unit of very low hydraulic conductivity. Through profiling, PCE was shown to be traveling downgradient through a small zone of high hydraulic conductivity. The heterogeneity of the subsurface resulted in concentration changes of 25,000 ppb to 0 ppb over only a few meters.

At Pease AFB in New Hampshire, where PCE and DCE were present, the two plumes were shown to differ in extent. The DCE plume was thicker and had no plume core at the source area. However, DCE accounted for greater than 60% of the chlorinated compounds in the source area. The changing parent to progeny ratios within the PCE plume indicate that it is degrading.

In conclusion, a good conceptual model is needed to properly characterize a plume. Contamination is controlled by subtle features at small scales so sparse monitoring networks can lead to erroneous conceptual models. Depth-averaged samples, such as those collected from long-screened monitoring wells, can also contribute erroneous information.

Integrated Characterization of a Trichloroethene Plume at the Idaho National Engineering and Environmental Laboratory

Kent S. Sorenson, Jr., Parsons Infrastructure & Technology Group, Inc.

Sorenson presented the work done to date to characterize a TCE plume at the Idaho National Engineering and Environmental Laboratory (INEEL) and to estimate natural attenuation rates using inverse numerical modeling. He explained that during the remedial investigation, there was an inadequate understanding of the behavior of chlorinated solvents and inadequate resources to perform the investigation. However, much work has since been done to obtain a truly integrated characterization of the plume.

The site is underlain by a 250-foot sole-source aquifer composed of many layers of basalt flows with occasional sedimentary interbeds. The basalt is vesicular at the top and base of each flow, and there is a stratification of contaminant concentrations. From the mid-1950s to 1972, waste liquids were injected into the aquifer. In 1987, the USGS detected TCE in production wells at INEEL, which was thought to be a result of past injection practices. In 1990, 55 feet of sludge, containing 3% TCE, 0.1% PCE, and radionuclides were bailed out of the injection well.

The conceptual model for typical chlorinated solvent plumes described by Cherry (1996) have two primary components: a high concentration core and a lower concentration fringe. Typical monitoring networks focus on the fringe, as did the monitoring network at INEEL. Most of the well clusters were positioned outside of the plume, and only one cluster was on the plume axis. This posed a problem because inadequate monitoring of the core leads to inaccurate estimates of contaminant mass and a lack of appropriate data for characterizing natural attenuation.

Seismic tomography paired with traditional geophysical logs, acoustic televiewer logs, and radar tomography were conducted at INEEL to better characterize the underlying geology. The results of the study confirmed that the cesium sludge was concentrated in the vesicular and fractured regions of the basalt. Pumping tests, packer tests, and tracer tests were conducted to characterize the hydrogeology. The results were used to back calculate aquifer parameters using inverse numerical modeling.

The results of modeling yielded mesoscale values for effective porosity, 0.05%; dispersivity, 2-20; and ambient velocity, 2.5 ft/day. These values are at least an order of magnitude different than macroscale results. As a result, it was a apparent that using macroscale values would lead to an improperly designed treatment system. It was concluded that characterization and modeling for site remediation must be tailored to the geology and the scale to be addressed. For DNAPL sites, it may be useful to approach investigation of the core and fringe of the plume separately. The additional site characterization did not alter the conceptual model of the plume; however, a more accurate picture of the plume's core was established.

The ground-water monitoring data was subsequently used to estimate natural attenuation rates. First, the source term for TCE was adjusted to match the expected plume extent for no degradation of TCE. The tritium plume that also is present at the site is similar to the TCE plume and was used to calibrate the model. The first-order decay equation was used with an adjustment to account for the movement of ground water by substituting a velocity term for time. The adjusted equation indicates that when the natural logarithm of the concentration ratio for observation wells along a flow path is plotted against distance between the wells, the negative slope of the plot is equal to the first-order decay constant (k) divided by the ground-water velocity (v). If the velocity is known, the gross first-order decay constant can be calculated. The first-order decay rate for the TCE plume was 0.0003/day, which corresponds to a half life of 6.3 years.

Reactive attenuation processes that occur in ground water can be delineated from this gross first-order decay rate. Reactive attenuation processes include those biological and chemical processes that attenuate a contaminant, but do not include equilibrium sorption or physical processes such as dispersion or dilution. There are two methods for calculating reactive attenuation rates: (1) Buscheck and Alcantar, 1995; and (2) Wiedemeier, *et al.*, 1996).

The Buscheck and Alcantar method assumes a stable plume, dispersivity and retardation have been quantified, and the transverse dispersivity is insignificant. By rearranging the solution to the general one-dimensional transport equation, including sorption, dispersion, and first-order decay from Bear (1979), and obtaining the ratio of k/v, the reactive attenuation rate can be calculated. The rate calculated using August 1997 TCE data at INEEL was 0.0003/day, which is almost identical to the gross rate. For a given k/v, the rate increases as dispersivity increases.

The Wiedemeier, *et al.* method assumes that an internal tracer (such as tritium) is available, the difference in transport properties of the tracer and the contaminant are understood, and the ground-water velocity can be estimated. The method calculates a reactive attenuation rate between two observation points that potentially accounts for dispersion, sorption, and volatilization by using internal conservative tracers in the plume that emanate from the same source as the contaminant. The contaminant concentration at the downgradient observation point is "corrected" for the effects of physical processes. After the correction is made, the difference in concentration between the two points is due only to reactive attenuation processes that do not act on the conservative tracer. If the contaminant behaves in the same manner as the conservative tracer, then the ratio of the contaminant concentrations will be the same as the ratio of the tracer concentrations. When this is true, the corrected downgradient concentration will equal the upgradient concentration, and no reactive attenuation is demonstrated. Thus, a plot of the ratios of the contaminant to the conservative tracer against distance can be used as an indicator of the existence of reactive attenuation processes.

The Wiedemeier, *et al*. method was applied to the TCE plume at INEEL, which has two potential tracers: PCE and tritium. PCE exhibits transport properties similar to TCE, while tritium is very conservative. Initial analysis of the ratios indicates that the tracers exhibit similar behavior, and that reactive attenuation processes appear to occur for TCE. The reactive attenuation rate was estimated to be 0.000175/day, which implies that TCE has a half-life of 10.8 years or less. Using this more conservative reactive attenuation rate (neglecting the effect of dispersion), concentrations near 3,000 ppb would be expected to reach the 5 ppb (the Maximum Contaminant Level) in 100 years, assuming source containment.

The upper bound of ground-water velocity also was calculated from the tritium data. By analyzing a plot of the logarithm of tritium concentrations against distance, the first-order decay rate for tritium can be calculated for a given velocity. If it is assumed that the only attenuation process for tritium is radioactive decay, then the first-order decay constant is known, and the ground-water velocity can be calculated using v=k/(k/v). Given that the first-order decay rate for tritium is 1.54 x 10^{-4}/day, and that k/v is 4.36 x 10^{-4}ft, the ground-water velocity is estimated to be 0.35 ft/day. The velocity can be adjusted to obtain the target half-life value (in this case 12.3 years). To avoid overestimating rates in subsequent calculations, a ground-water velocity of 0.30 ft/day was used to calculate travel time between wells.

Question and Answers

Question: Did you try to put different degradation rates into the equation to show the half-life in different parts of the plume?

Answer: This has not been done because the code would have to be modified for a spatially dependent half-life.

Question: Can the half-life be determined from the existing monitoring data?

Answer: Yes, because about 10 years of data have been collected. The data show that the half-life of the TCE has decreased over time, perhaps due to altering the source (*e.g.*, removing the sludge from the injection well).

Question: Were tracer tests conducted along the axis of the plume?

Answer: Circulating force gradient tracer tests were performed. The gradient at the site is very low—about 1 foot/mile. Two types of tracers were used: fluorescent dyes and bromide and iodide.

Roundtable Discussion: Site Characterization for the 21st Century

Curt Black (Region 10) and Kay Wischkaemper (Region 4) moderated the Roundtable discussion entitled *Site Characterization for the 21st Century*. The purpose of the Roundtable was to bring together a group of experts to discuss current topics of interest in site characterization.

This Roundtable discussion is the fourth in a series of TSP Roundtables. Previous Roundtable topics were *in situ* thermal treatment, thermal desorption, and permeable reactive wells. The discussion was organized around three questions prepared by the Ground water Forum. The six Roundtable panelists were:

- Gary Hopkins, Stanford University
- Forest Lyford, USGS
- Seth Pitkin, Stone Environmental, Inc.
- Sheridan Haack, USGS
- Carl Keller, Flexible Liner Underground Technologies, Ltd.
- Kent Sorenson, Parsons Infrastructure & Technology Group, Inc.

Question 1. Traditionally there has been an emphasis on defining plume boundaries. Is this the proper emphasis for site characterization or should more be done to understand the internal plume anatomy? If so, why?

Gary Hopkins said that the answer depends on your goals at the site. If you just need to know what contaminants are there, then focus on defining the boundary of the plume. If you need to determine natural attenuation or intrinsic bioremediation, then you need to look at the anatomy of the plume. Sheridan Haack agreed that it depends on your goal. To determine whether a regulated contaminant is migrating to a point of exposure, you need to know the plume boundaries. To understand how the plume got to where it is, you need to study internal plume processes. At some point, you need to focus on the major axis of the plume. Forest Lyford noted that you need to understand internal plume anatomy to design an active remediation project. Seth Pitkin said that information on both plume boundaries and internal anatomy are needed. In the past, the focus was on the boundary to the exclusion of the plume core. Understanding what is going on in the source area makes it a lot easier to determine plume boundaries. Kent Sorenson commented that you need to focus on plume boundaries from a risk characterization standpoint. But to make predictions of the future vertical and horizontal extent of the plume, you have to study the core of the plume. Carl Keller noted that looking at the core enables you to define the source term, determine the magnitude of the problem, and evaluate the effectiveness of remediation. It also helps you locate the low contaminant concentrations at the perimeter of the plume.

In the discussion following panelist comments, Curt Black said that information on the source is needed to determine whether natural attenuation will occur in a reasonable time frame. In regard to natural attenuation determinations, a Roundtable participant asked about the importance of evaluating the stability of a plume as compared to its internal anatomy. Pitkin responded that, if you do not understand plume anatomy, you may believe that more degradation is occurring than is actually occurring. Sorenson commented that you must understand internal processes to know what plume stability means. If there is a connection to surface water, natural variability will effect predictions over time. Sorenson said that he is not sure that the stability of a plume is the most important factor in natural attenuation determinations. Haack noted that we know a lot about conditions under which BTEX compounds (benzene, toluene, ethylbenzene, and xylenes) degrade and can make some predictions; however, changes in regional flow paths over time may affect predictions. In addition, we know nothing about a many other contaminants and degradation processes. We need to know the forcing functions of internal plume processes.

Keller said that there is a big difference between the eastern and western parts of the country regarding the perception of problems in the vadose zone. Vadose zones in the west typically are much deeper than in the east. There is a lot of contamination leaching from landfills that is still in the vadose zone and has yet to reach ground water. Keller emphasized that, in the west especially, subsurface contamination problems are not limited to ground water. There is a need for more vertical measurements in the vadose zone. Currently, this is only about 10% of subsurface characterization work. Pitkin added that, although the focus is currently on vadose zone leaching to ground water, there also are sources in the ground water that should receive more attention. David Kargbo (Region 3) said that vadose zone issues also are very important in the east. It is very difficult to track DNAPLs in Pennsylvania's fractured bedrock. Also, variability is greater in the vadose zone than in ground water. Guidance should focus include residuals in vadose zone that continue to act as a contaminant source.

Ruth Izraeli (Region 2) commented that she has encountered DNAPL situations that may be too complicated to characterize for remediation purposes. She asked why these sites should be characterized if the site will not be cleaned up? Pitkin noted that most of sites he has worked on are sites that already had been characterized, but not well enough to understand what was going on. Detailed characterizations should be done in the beginning rather than 5-6 years later. Sorenson said that detailed characterizations are needed to find the best clean-up solution. The amount of effort to put into characterization depends on how you are approaching the site. If the remedial goal is stringent and heterogeneity is high, you need to do the work to understand internal plume anatomy. Dick Willey (Region 1) agreed that the intensity of an investigation depends on your goal. Willey said that he found vertical distributions of DNAPLs that were far different from what was expected at the Savage Municipal Water Superfund site in New Hampshire. In response, he monitored every 3 feet in the source area because clean-up times and efficiencies are directly related to where in the plume extraction wells are placed.

Haack commented that the gas/water interface may be an important area for some degradation processes. Also, the surface area of a ground-water plume may be a large area that is important for degradation processes. Haack noted that she has not seen anyone include these areas as active zones in remediation models.

Question 2. What are the best field techniques to evaluate plume anatomy, and at what scale or sample intensity should this be performed?

Keller said that determining the best field techniques depends on many factors, such as the types of contaminants. Because water wells are expensive measurement technologies, you should get the most information you can from them. A continuous record and avoiding the migration of contaminants are desirable. Keller suggested using horizontal wells to determine heterogeneity along the flow path. Horizontal wells are less expensive and do not muddy the medium as in the past. He added that push technologies are useful for profiling. Sorenson said that having the option to leave a well open would very helpful. The scale and intensity of sampling is dependent on your goal and the subsurface environment. Intense sampling would not useful for a basaltic flow where processes may or may not vary over six inches or ten feet. Pitkin said that a toolbox of technologies is needed. Some technologies work well in some settings but not in others depending on your goals and contaminants. Regarding the scale of sampling, you need detail at the source. If variability is low, you can make the scale larger; however, there are no rule-of-thumb solutions. Lyford commented if you can determine the geology and hydrogeology, you can make better predictions of contaminant locations. Borehole geophysical methods, such as electromagnetic conductance can be useful in characterizing the extent of contamination. Haack said that you need senior scientists in the field, particularly at the start of a project. Better interpretation of data will lead to better choices about what additional information needed and better placement of wells.

A meeting participant noted that geophysical methods work well if you can leave the hole open long enough. The participant asked whether everting liners could be used to limit vertical migration. Carl Keller said that they could and that everting liners are being used at a site in New Jersey for this purpose.

Question 3. Passive sampling techniques are becoming more common in use. What is the proper role of these techniques versus active extraction methods and how should a passive sampling program be implemented?

Hopkins said that, as an analytical chemist, he considers most passive technologies to be qualitative technologies. While they can help determine the presence of contaminants, their use will not be accepted by regulators for monitoring because of their lack of accuracy. Sorenson said that diffusion samplers work well in determining vertical variability, although caution should be exercised when applying them. He said that there are a lot factors can affect their quantitative performance. For example, de-gassing of samples can occur when brought to the surface from a deep well sampling point. Lyford said that he would not want to use passive diffusion samplers as monitoring devices, though he has more confidence in water diffusion samplers. Keller said that he has done some passive sampling to get spatial information that he could not get from quantitative data. Colorimetric techniques can be useful in obtaining spatial information. Passive samplers need to be well-isolated. Also, passive samplers that equilibrate with pore gas must be used with care, because vadose zone measurements will be affected by whether air is flowing into or out of the vadose zone. Keller noted that the proper place for passive samplers is to give you an idea of conditions at a reasonable cost. Sorenson said that passive sampling can provide profiles in hard rock zones. It is not practical to obtain quantitative data on a 6-inch scale in deep bedrock. Sorenson said that he has used cumulative samplers to indicate the passing of a fluorescent dye pulse in a karst environment. The dye pulse can be easy to miss unless you use conducting continuous sampling.

Pitkin questioned why anyone would use a passive technology when you can get real-time data with active technologies. Wischkaemper responded that leaving a passive sampler in place for a week gets you an average rather than snapshot. Judy Canova (SCDHEC) said that South Carolina uses passive samplers because they are much cheaper and the analytical costs are cheaper for a gas sample than a water sample. Pitkin said that the expense of active sampling depends mainly on how you choose to analyze your sample. He believes that passive sampling introduces a lot of unknowns. Willey said he believes that cost will drive the agency to do more passive sampling. The biggest problem with passive sampling in a well is where there is movement of water up and down the hole.

Keller commented that there is no point to intensive sampling to gain a higher resolution unless it will end up saving money. The presence of DNAPLs is a good justification for trying to gain a higher resolution. Pitkin noted that the real reason we are looking for better resolution is that the private sector has been forced to spend billions on remedies that do not work. The private sector wants a solution that will end the problem. Sorenson commented that this is not just a private sector issue. For example, DOE only has a certain amount of money to spend on cleanups, so they are concerned about costs too.

OPTIMIZATION OF GROUND-WATER TREATMENT SYSTEMS: FOCUS ON SOLVING PRACTICAL FIELD PROBLEMS

Robert Saari, Steven White, and Lindsey Lien, USACE

Robert Saari, Steven White, and Lindsey Lien of the USACE presented a short course focusing on solving problems in the field related to extraction wells, metals removal, advanced oxidation process, carbon adsorption, and injection wells. The presenters used a case study from the Milan Army Ammunition Plant (AAP), Tennessee, to illustrate problems encountered and lessons learned.

The Milan AAP is a 22,000-acre facility constructed in 1941 for the production of fuses, boosters, and small and large caliber ammunition. It remains an active AAP. The O-Line Ponds area is a 5-acre site that was used from 1942 -1978 to settle explosive compounds. The site was formally closed in 1984 and was placed on the National Priorities List in August 1987. On-site pilot-testing began in summer 1992 following five years of investigations and studies. The ROD for the site was signed in September 1992 and a construction contract was awarded in December 1993.

Ground-water contaminants include TNT and RDX, with concentrations of total explosives up to 25 mg/L. The site also has potential for low levels of heavy metals. The ROD called for extraction at 6,000 gpm, treatment by electrochemical precipitation, UV-oxidation, and carbon adsorption, and then re-injection. Construction was completed in the fall of 1995 and start-up was completed in the fall of 1997. It has been operating at design since November 1997.

Extraction Wells

White explained the operational and installation problems with extraction wells at the site and how the USACE addressed the problems. Because holes were not plumb and there were no centralizers installed, the filter packs were uneven and the screens were too close to the formation. White said the extraction wells were not developed properly, and stressed the importance of adequate well development. This involves running the pump along the entire length of the boring for a long period of time. He said another development-related problem occurred because the extraction wells at Milan sat idle for several weeks before they were operated. This caused the fines in the wells and the formation to harden and cement to the formation. Once this happened, they could not be removed, and well yields were permanently reduced.

The two original wells were beset with a number of operational problems. Formation water was drawn down into the screen level, which introduced oxygen into the formation, leading to biofouling and reducing ground-water flow. The contractor had no plan for well O&M. White explained that PRPs should be required to pull and clean the well and pump periodically. While many PRPs will claim they cannot do this because it will void the manufacturer's warranty, the equipment used at Superfund sites is not covered under warranty anyway.

The lack of observation wells also caused a number of problems. Observation wells with piezometers close to the extraction well are necessary to determine the cone of depression or mounding. Observation wells also can be used to inject chemicals that are drawn through the pores of the formation to kill bacteria that contribute to biofouling of the well. It is necessary to use the observation wells because placing chemicals in the extraction well will clean the screen, but usually will not clear bacteria in the surrounding formation.
New extraction wells are being installed at Milan AAP. These wells will be screened at 55-90 feet below ground surface, about 10 feet lower than the original wells. The screen always will be saturated in order to reduce the chance of biofouling. The new wells will be vigorously pre-developed during installation of the filter pack, so fines remain fresh and accessible and have no opportunity to build up permanently on the formation. The contract calls for 100 percent technical oversight by a senior scientist.

In response to a question, White said biofouling can be especially bad at sites with light non-aqueous phase liquids (LNAPLs) because bacteria form in a thin layer at the water/fuel interface. He suggested limiting development to the water layer and leaving the fuel layer alone.

Ground-Water Treatment of Inorganics Using Electrochemical Precipitation

Saari outlined treatment alternatives for aqueous-phase heavy metals. These include chemical or electrochemical precipitation (ECP), ion exchange, adsorption, separation/filtration, and membrane technology. He explained that electrochemical precipitation, which was one of the treatment technologies used at Milan, is an alternative to conventional precipitation, ion exchange, or membrane technologies. The process has been used in the metals finishing, printed circuit board, and textile industries, but is a relatively new process for ground-water remediation. ECP involves pumping ground water through an electrochemical cell with parallel plates. Electrical current is applied to steel electrodes, which release free ferrous ions that attract contaminants and promote co-precipitation. Contaminants are removed through co-precipitation and adsorption.

There are several advantages to ECP. It can achieve lower residual levels than conventional methods and can remove multiple metals simultaneously at a single pH. Vendors claim that the process produces a lower volume of less hazardous sludge, but these claims have not been proven in practice. Disadvantages include higher capital and operational costs.

Saari showed slides of the treatment unit. He outlined several lessons learned, including the need to replace electrodes regularly (about every 45 days). Factory wiring should be checked to establish base settings for the operation of the clarifier. Controlled start-ups and frequent jar tests should also be performed. Saari explained that the addition of sodium chloride to the process caused problems that contributed to chemical fouling of the well. He said sodium chloride has potential to react with clay and to cause sodium exchange with calcium-based clays. Sodium chloride also causes clay swelling and reduces permeability. He concluded by emphasizing the need to move beyond a “black box” approach to writing specifications and to base decisions on full knowledge of processes and site characteristics.

Advanced Oxidation Process

Lien presented design considerations for advanced oxidation processes (AOPs). He noted that the process produces OH^{-} radicals for oxidation of organic contaminants when the oxidizer absorbs light from UV lamps. The oxidizer type is defined by the type of UV lamp used. Because ozone was used as the oxidizer at Milan AAP, ozone gas had to be generated on site, and the system design had to consider saturation limits, collection points in sumps and contractors, and ozone off-gas destruction systems. Lien indicated that AOP at Milan produced excessive ozone concentrations at start-up and advised conducting start-up at lower rates. Lien noted design impacts of selected equipment for AOP. Building size and site development should be considered and the site design must allow for proper maintenance of equipment. He pointed out that supplemental cooling may be necessary and advised phasing the construction schedule around equipment deliveries because of the long lead times for AOP equipment. Ozone units must be placed prior to construction.

Lien emphasized the value of partnering agreements that include all parties involved from the start, so that everyone knows what needs to be done and who is responsible for it. An O&M manual should be prepared that addresses individual components, the overall AOP system, and how it fits into the overall plant. Many AOP systems come with computer packages, but compatibility issues must be addressed in advance to ensure that they can be integrated with other computer systems.

Lien described a variety of maintenance considerations and operability issues and noted the need to consider organic fluctuations in the system. He said the O&M manual also should address what happens when something in the system fails. Lien outlined a number of lessons learned, including the need to conduct a variety of tests at equipment start-up, including an operational test, leak test, clean water operational test, and a dirty water operational test. He said that vulnerability analysis also should be included in start-up specifications.

Carbon Adsorption

Lien indicated that carbon adsorption could have been used alone at the Milan AAP, but the ROD specified the use of both ECP and carbon adsorption processes. The use of activated carbon was critical when the AOP system was not operational.

Treatability studies conducted at Milan in the late 1980s provided good data to determine sizing and loading for the system. Lien recommended that such studies be conducted at the same pH expected at a site. At Milan, there were three carbon vessels, including one for changeout. However, there has been no need for changeout since the system began operation in 1995.

There have been relatively few problems with the system, and those that occurred resulted from the use of ECP. One of the lessons learned at the site was that ozone carryover from other processes used at the site created problems because ozone reacts with carbon. Because carbon absorbs oxygen, proper ventilation and attention to space specifications is critical. Lien emphasized the need for pretreatment, even in the vapor phase, and said that provisions should be made to allow for backwashing of the system site on, which was not the case at Milan. He advised against on-site regeneration unless absolutely necessary. He noted that even with the introduction of new technologies, carbon adsorption systems are still "tried and true" and are used more than ever.

Several USACE documents, including Guide Specifications for AOPs-11377 Chemical Oxidation Process; Engineering Technical Letter 1110-1-161 Ultraviolet/Chemical Oxidation; and Guide specifications for GAC-11225 Downflow Granular Activated Carbon, are available on its Web site:
http://www.environmental.usace.army.mil/environmental/publish.html.

Injection Wells

White described the use of injection wells at Milan AAP, the problems encountered, and how they were addressed. He said many plants never get the level of contaminants there are designed for because pump tests are not conducted. He recommended conducting 8-, 12-, 24-, and 72-hour pump tests near the area of maximum contamination, rather than relying on data form a sampling well. He said that had pump tests been conducted at Milan, the use of ECP to remove heavy metals at the site never would have been justified.

White explained that the injection wells at Milan clogged for a variety of reasons. There were suspended particles and gas bubbles in the water. Adding iron and oxygen to water for the ECP process caused bacterial infestation. Sodium chloride also was used in the ECP process, which caused swelling and depression of clays. Clogging also resulted from hydrofracturing and chemical precipitation.

It is critical to know what will come out of the ground before injecting water into it. Mixing dissimilar waters can cause chemical reactions that can lead to system clogging, while in other cases, the chemical reactions can be beneficial to the system. It is important to know what is likely to happen beforehand.

White described the Blended Chemical Heat Treatment (BCHT) technology used to treat the biofouled injection wells at Milan. The technology, which uses chlorine gas, was very successful. During the shock phase, hot chemicals are jetted through the entire length of the well and allowed to remain there for 24 hours. Then a second injection is used to improve convection for deeper penetration of the chemicals. During the dispersion phase, the well is developed. How well the pumping and surging during this phase works depends on how well the injection well was developed in the first place. The injection wells at Milan are now fully functional following the treatment. Observation wells have been installed and changes have been made in the process to clear effluents.

White pointed out that the BCHT technology is a rehabilitation process and is not appropriate for routine maintenance. He noted that if routine maintenance is conducted, such a vigorous treatment would not be necessary. He recommended that routine maintenance be conducted on a quarterly basis or every four months to prevent biofouling of injection and extraction wells. The maintenance interval can be increased if no problems are detected, but maintenance probably is necessary whenever a 10% drop in expected capacity is observed.

The USACE is developing guidance on problems with extraction wells which should be available soon. White will ensure that the Engineering Forum is made aware of their availability.

THURSDAY, JULY 16, 1998

FIELD TRIP TO ABERDEEN PROVING GROUND, ABERDEEN, MARYLAND

The TSP Forum members visited the Aberdeen Proving Ground (APG) located northeast of Baltimore, Maryland on the western shore of the Chesapeake Bay. APG occupies more than 72,000 acres and was used by the U.S. Army for the production and testing of weapons, ammunition, and materials. Numerous areas of the property are contaminated with chemicals, hydrocarbon fuels, and UXO.

Colonel Wiener of the Army Environmental Center (AEC) welcomed the TSP Forum members to APG and explained AEC's role in remediating the site. The Forum members then split into two groups in order to tour the APG. John Robe and Cynthia Powels, environmental engineers at APG's Directorate of Safety, Health & Environment, provided narrative descriptions of the history, operations, and environmental issues at APG. The J-Field, O-Field, and Lauderick Creek sites were visited.

J-Field

The J-Field was used to dispose and burn warfare and industrial waste chemicals from the 1940s to the late 1970s. The chemicals were segregated into three pits: riot control, white phosphorous, and toxic burning pits. The ROD has been signed for the J-Field, and the lead-, arsenic- and PCB-contaminated soil has been excavated. The pits will not be capped; instead, a protective soil cover has been installed to isolate the residual contaminated soil. The excavation work at the pits is being conducted in Level B personal protective equipment.

Ground-Water Remediation:

Harry Compton and George Prince of EPA's Environmental Response Team provided an overview of the ongoing ground-water remediation efforts at the toxic burning pit. The toxic burning pit is an approximate 800-ft by 500-ft area consisting of several tenches. A plume of chlorinated solvents originating from the pit is migrating slowly through the surficial aquifer toward the nearby Chesapeake Bay. The plume is being treated by a combination of phytoremediation and recirculation wells. Phytoremediation is conducted for about 6 months of the year (during the growing season) to intercept and destroy the VOCs; the recirculation wells are used during the remainder of the year. A horseshoe-shaped line of poplar trees about 8-10 feet high and 1 inch in diameter was planted two years ago. Since then, the trees have grown 200%. From February to October when the water table drops approximately 8 feet, the tree roots grow up to 1 inch per day to reach the water.

Only a few of the trees are being exposed to high concentrations of chlorinated solvents (up to 500 ppm). The transpiration gases of all of the trees are being sampled for chlorinated solvents, and leaf tissue is being sampled to assess the presence of VOC metabolites. The levels of VOCs emitted at the ground surface are being sampled with stainless steel chambers, and ambient levels are being monitored by Open Path Fourier Transform Infrared (OP-FTIR) spectroscopy. Sap flow rates are being measured, and the nematode population is being studied. Sampling of lysimeters and monitoring wells is being performed to monitor the effectiveness of phytoremediation in treating the plume. Thus far, based on monitoring results it appears that phytoremediation is successful at containing and removing VOCs from the ground-water plume. TCE is being emitted at the ground surface and requires further study.

Geophysical Studies:

George Prince and Noel Rogers (Weston Geophysical in Albuquerque) explained the geophysical techniques being used at the J-Field to map the migration of the plume from the toxic pits to the Chesapeake Bay. First, the area was surveyed for buried unexploded ordnance. A geophysical platform was constructed with magnetometers and metal detectors on the front identify possible UXO, and a Global Positioning System (GPS) was used to determine location. The survey area was about 20 meters wide into the Bay. A subsequent infrared survey data provided by Martin Marietta identified where the plume was discharging. A robotics mechanism is being developed to do remote sensing at other sites.

O-Field

The O-Field is a 4.5-acre site used from the late 1930's to 1953 for the disposal of conventional and chemical munitions, contaminated research and production equipment, and bulk chemicals such as mustard gas and white phosphorous. The landfill consisted of 35 burial trenches. Effluent from the landfill drains into Watson Creek, which empties into the Gunpowder River. Ground water is contaminated with metals, chlorinated solvents, degradation products of chemical warfare materials, and explosives.

Landfill Cap:

The landfill contents are too dangerous and explosive to remove; therefore, the landfill will be treated in place. The landfill was capped a few years ago with a permeable infiltration unit to prevent fires from occurring. Initially, the stability of the landfill was tested using a tele-operated excavator and bulldozer. The equipment was also used to knock down trees and install the first layer of sand atop the landfill. The 5-foot sand layer was installed to contain explosions. A subsurface trickling system was installed within the sand layer. In the future, it will be used to flush chemicals to the wastewater treatment plant. A geotextile layer was installed over the sand layer to prevent air from infiltrating and setting off the buried picric acid fuses. The geotextile was covered with 6 inches of aggregate. The landfill cover is equipped with a sprinkler system, which would be activated upon a release of a chemical agent. The sprinkler system is capable of delivering 1,000 gpm from a 200,000-gallon tank. Releases of two nerve agents and mustard gas are being monitored.

For further information on the landfill cap, please contact Cynthia Powels at (410) 671-4568 or 4429

Bee Colony:

Jerry Bromenshenk, Professor of Research at the University of Montana, described the use of honeybees to measure environmental contamination at the O-Field landfill. The premise of using honeybees is that the bees pick up elements of their surrounding environment, such as pollen, nectar, water, and air, when they forage.

Electronic beehives have been built near the O-Field landfill to house the beehives and monitor their comings and goings. On average, 95-98% of the bees return to the hive each day. A less than average return may indicate that an environmental problem exists. The system takes into account weather as a factor for the rate of return.

The bees may release pollutants that they have picked up outside the hive when they fan the air with their wings to regulate their temperature. Copper tubes connected to the beehives pump out air for pollutant analysis. The air is pumped out to filters that trap the organic components. The filters are then heated and the VOCs analyzed by GC/MS. The results are compared to those obtained at reference beehives located on a farm about 2 miles away.

For further information on the beehive work, please contact Dr. Jerry Bromenshenk at (406) 243-5648

Ground-Water Extraction and Treatment System:

A ground-water extraction and treatment system was completed in April 1995 to treat the contaminated ground water from the O-Field. A series of about 14 active extraction wells bounding the north and east sides of the O-Field pump 20 gpm to storage tanks. The treatment plant can then operate at 32 gpm and be shut down for periods that the tank is refilling.

The groundwater first passes through a metals treatment phase in which the pH of the water is raised to 10.2 to precipitate metals. The metals precipitate goes to a sludge holding tank and filter press prior to disposal. The water then passes through the organics treatment phase, which consists of an air stripper followed by an ultraviolet oxidation reactor. Any remaining organics are removed by liquid phase carbon. The treated water or effluent is neutralized with NaOH and H_2SO_4 and placed in storage tanks before being discharged to the Gunpowder River.

The toxicity of the effluent is continuously monitored by measuring the breathing patterns of blue gill fish. Effluent is continuously fed to a tank containing the fish. The cough patterns and body movements of the fish are then monitored to identify any stress that might be caused by the presence of contaminants. If six of the fish show signs of stress, an alarm is sounded; if four of the six fish die, the system automatically shuts down. The treatment plant has shut down three times in its three years of operation; two of these times were related to maintenance activities.

This effluent monitoring system is seen as an improvement over conventional sampling and analysis systems because slugs of contaminants in the effluent discharge will not be overlooked. Water quality parameters that affect fish, such as temperature, pH, conductivity, and dissolved oxygen, are also continuously monitored.

For further information on the effluent monitoring system, please contact Dr. Henry S. Gardner, Jr. at (301) 619-7685 or Henry_S_Gardner@ftdetrck-ccmail.army.mil.

Lauderick Creek

Billy Saunders (USACE) provided an overview of the removal action at Lauderick Creek, which is a ¼-mile wide, 450-acre area that includes a former Nike missile facility. The site is a concern because it contains buried chemical weapons and UXO and borders a residential area, schools, a daycare center, and an Amtrak rail line. Releases of chemicals such as phosgene and mustard gas or detonations of ordnance can potentially impact people in the vicinity. Therefore, a Protection Action Plan was prepared for the site.

The site was cleared of brush and metallic objects on the ground surface. A TM-4 imaging magnetometer was used to survey the site for buried metal objects. The survey was conducted on 60-meter grids and to a depth of 36 inches to consider the possible effects of frost heaving. Approximately 22,000 magnetic anomalies were detected. The data were refined by Sanford Cohen & Associates, who indicated the presence of 10,000 anomalies. These anomalies will be cleaned up. The others will be considered by an Anomaly Review Board before a decision to remove them is made.

Ed Newell, the Project Oversight from USACE, explained the garrison the runs the removal action at Lauderick Creek. He noted that much of the UXO at the site will be removed and transported to the prototype detonation facility to be constructed near the J-Field. Other UXO cannot be moved and will have to be detonated in place. However, munitions such as the World War I Livens projectile contains 28 pounds of phosgene (requiring 144 pounds of explosives to explode) and cannot be safely detonated in the vicinity of residences and the railroad. It is proposed that such munitions will be detonated inside a primary tent filled with an aqueous foam and surrounded by a larger secondary tent in case fragments escape the primary tent. The tents would be constructed of a Kevlar® fabric. Munitions that are brought to the prototype detonation facility would also be detonated inside these tents. The tents are currently being tested. If an escape of gas occurs, water cannons will spray water in the direction of the wind to break up the gas cloud. The cost of the tents is $15K, which includes the cost of a blower, but not filters, *etc*. The tents can only be used once on mustard gas munitions, but can be reused for phosgene munitions.

Paul Green (Human Factors Applications) explained that the Anomaly Review Board will look at all of the data and provide him with a “dig sheet” that identifies which items should be excavated. His group will remove and dispose of the conventional weapons or scrap metal, but will turn other items over to the Technical Escort.

The excavation cannot be performed before 7:00 am or after 2:30 pm because students come and go from school at those times. The protection of the rail line, eagles, and wetlands must also be considered.

John Lyon (Foster Wheeler) described the telemetry system being developed to view detonation operations remotely. The system will be pointed toward the open-front barricade and will be able to pan and tilt. The system costs $16K, and the associated hard wire system along the telephone lines costs $20K.