FEDERAL REMEDIATION TECHNOLOGIES ROUNDTABLE MEETING
Arlington, Virginia
May 2, 2007

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ACTION ITEMS

- All members are requested to review the draft EPA fact sheet, "Remediation Case Studies and Technology Assessment Reports," and send any comments to John Kingscott by June 1, 2007.
- EPA will develop an approach for updating the FRTR web site and contact members for their input. This would include reorganizing the information to distinguish components that are being actively updated.
- Member-agencies should notify USACE/EPA when web links need to be updated/replaced and when new reports are available.

WELCOME/OPENING REMARKS

Norm Niedergang, new Director of the Technology Innovation and Field Services Division (TIFSD) in the U.S. Environmental Protection Agency (EPA) Office of Superfund Remediation and Technology Innovation (OSRTI), welcomed the attendees to the 34th meeting of the Federal Remediation Technologies Roundtable (FRTR) and provided a brief overview of the agenda. An open teleconference phone line has been provided for additional member-agency staff to participate in the technical presentations for this meeting. Niedergang indicated that all member-agencies present would be asked to cast ballots on important topics for technical sessions at the next meeting. He said the results would be announced at the end of this meeting.

Attendees introduced themselves.

FRTR MEMBER ANNOUNCEMENTS

Norm Niedergang provided updates for EPA. They included:

Triad—EPA remains very active in its ongoing collaboration to advance best practices. Activities include

- The Interstate Technology Regulatory Council (ITRC) is completing their second technical guidance document on Triad for state regulators.
- EPA is now hosting regular, monthly calls among EPA Regional contacts on Triad issues, educational activities, and progress at Triad sites in addition to monthly Triad Community of Practice calls, which involve state and private sector Triad practitioners.
- EPA is pursuing an active Triad training program. Staff recently completed a series of training deliveries in California for regulators (Dept. of Toxic Substances Control and regional Water Boards). The Agency is completing two courses: Triad "101," an introductory, 1-day course for less technical audiences (Brownfield's, land revitalization, new project officers); and a "301" version for more experienced project managers. Both should be available for delivery by the end of the fiscal year.

Decision Support Tools—New decision support tools include:

- ProUCL─Parametric and Non-parametric 95% confidence level calculation as in EPA UCL Guidance.
- Mass Flux Tool Kit─Process for calculating long-term mass flux

- Rapid Assessment Tool─Integrated real-time visualization, data capture directly from devices
- Wellhead Analytic Element Model (WhAEM) 2000─Groundwater flow model; facilitates capture-zone delineation
- Biobalance Toolkit─Applies mass balance approach to sites with solute transport models
- Final report ("Development of DST Matrix")─Describes process of evaluation and describes tools selected

University of Massachusetts Conferences Grant—This five-year award will allow the university to host national technology conferences. The first of these will be a national Triad meeting in 2008. Niedergang solicited topic areas for these conferences and offered members partnership opportunities.

National Ground Water Association Fractured Rock Conference Grant—EPA is hosting this conference, which focuses on state-of-the science and measuring success in remediation, September 24-27, 2007, Portland, Maine

Ken Skahn (EPA/OSRTI) reminded attendees that there is a standing Environmental Cost Estimating Committee that is part of the FRTR. The committee is comprised of about 30 members from nine agencies. They usually meet through conference calls and their mission is to develop software costing tools such as RACER. Among other activities they have developed a method for producing efficient work breakdown structures to track construction costs; are standardizing agency environmental liability audits; and are considering cost savings initiatives such as value engineering and tax exemptions for construction equipment. They are on the FRTR web site at http://www.frtr.gov/ec2/index.htm

ROUNDTABLE TECHNOLOGY COST & PERFORMANCE EFFORTS

John Kingscott (EPA/OSRTI) said the Technology Cost and Performance page on the FRTR website (http://www.frtr.gov/costperf.htm) is a unique collection of information as it summarizes the federal characterization and cleanup experience. This year they have added 38 new case studies and reports. The website contains a searchable database with 394 reports on groundwater and soil treatment applications, 75 remedial technology assessment reports, 175 reports on innovative site characterization and monitoring technologies, and 110 reports on optimization case studies. Kingscott recognized the U.S. Army Corps of Engineers (USACE) in Omaha, which serves as webmaster for the site, and thanked all agencies that have contributed information for case studies.

Kingscott noted that some sections of the FRTR website are being maintained aggressively, while others do not appear to have been updated for five years or more. He said EPA is looking at ways to restructure the site or identify which sections should be updated and which should be eliminated or downplayed. He also asked that members provide suggestions for how to address areas that are no longer current. In addition, he asked that all member-agencies evaluate their agencies' descriptions on the website and inform the USACE/EPA of any changes needed. He also asked that all member-agencies notify USACE/EPA when web links need to be updated/replaced and when new reports are available.

Kingscott asked representatives of all FRTR member-agencies to review a draft fact sheet, "Remediation Case Studies and Technology Assessment Reports," that highlights the new case studies and reports. He would like comments back by June 1. The comments can be in any form (hard copy mark-up, electronic). He indicated that copies of the completed fact sheet would be provided to all members and encouraged them to distribute it within their agencies. He also asked that all member-agencies help identify opportunities for new case studies; EPA has contractor support to prepare the reports.

Questions/Comments

Tom Nicholson, Nuclear Regulatory Commission (NRC), said that Pacific Northwest Laboratory looked at an old uranium mill tailings remedial action site (UMTRA) in Rifle (CO), and prepared a report evaluating performance indicators to monitor to determine if *in situ* bioremediation was occurring. He will provide a link for that report to be added to the FRTR site.

Beth Moore, U.S. Department of Energy (DOE), said that because of the work done at the Rifle site, DOE is sponsoring research and demonstrations at other sites for the bioremediation of metals and radionuclides. She added that at some point she would like to have an FRTR meeting that showcases this work. In addition, DOE is re-establishing an applied research program at Savannah River to aid in the transfer of the agency's basic research program results. DOE and NRC are very interested in sediment and soil recovery of radionuclides and metals and EPA should see an emphasis in these areas from them. The DOE research program also has a new website (http://www.em.doe.gov/Pages/EngTech.aspx) where new developments are posted.

DENSE NON-AQUEOUS PHASE LIQUID (DNAPL)

DNAPL OVERVIEW— PROGRESS AND CHALLENGES

Jim Cummings (EPA/OSRTI) began the DNAPL technical session with an overview of DNAPL remediation history and progress (Attachment A). Because they are hydrophobic and can migrate as a liquid through both unsaturated and saturated soils, DNAPLs are difficult to detect and remediate. A New York Department of Conservation study of manufactured gas plants found that coal tar liquids had migrated off site in 60 to 70 percent of the sites. The most ubiquitous DNAPLs are those formed by the chlorinated solvents trichloroethylene (TCE), such as degreasers, and tetrachloroethylene (PCE), such as drycleaning fluid.

Only in the last five years have effective non-aqueous phase liquid (NAPL) remediation technologies begun to mature. Before then, while some experimentation was being done, containment by a pump-and-treat system (P&T) was the only effective way to address NAPLs. Estimates of how long cleanup would require stretched to 100s of years; many feasibility studies assigned 30 years as a minimum. Given that EPA turns P&T operation over to the states after 10 years, the estimate of long periods of paying for the operation and maintenance of these systems has concerned state government. The Navy also has recognized the potential costs of long term P&T operation and has a policy in place that requires headquarters approval of any new proposed P&T remedies.

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In the mid-1990s, EPA dealt with DNAPL presence with technical impracticability (TI) waivers. If a DNAPL was present it would be too expensive or technically infeasible to clean up. TI waivers, while relieving the responsible party of the task of completely removing or destroying DNAPLs, do not relieve them of the expensive responsibility of containing the dissolved phase contaminant plume. Evidence now is that there are technologies available that can effectively remove or destroy some DNAPLs *in situ* in some geologic settings.

Monitored natural attenuation (MNA) of petroleum products (especially BTEX) saw successes in the 1990s. The attempt to use it with chlorinated ethenes, however, has been met with some skepticism. It works in some cases and not in others; however, some source zones can be modified so that MNA is an effective polishing technology for the weakened dissolved phase plume.

New technologies that are maturing and have been shown under several field scenarios to be potentially effective for *in situ* DNAPL cleanup are thermal, chemical oxidation/reduction, surfactant/cosolvent flushing, and bioremediation. There are still some growing pains with some of the technologies, and for some sites, a flexible, adaptive combination of remedies appears to be a good approach. There also appears to be more interest in the private sector. They want to avoid protracted P&T operation and are willing to spend more money up front to achieve this, especially if redevelopment issues are involved.

Cummings believes that future DNAPL cleanups will have an adaptive, flexible implementation that uses technologies to complement each other as the remediation progresses, and rely more on 3-D visualization and Internet-based tools for decisionmaking.

SERDP/ESTCP DNAPL RELATED R&D/DEMONSTRATION PROJECTS

Andrea Leeson, Strategic Environmental Research and Development Program (SERDP) and the Environmental Security Technology Certification Program (ESTCP), explained that SERDP performs the research on various topics, and ESTCP demonstrates the technologies (Attachment B). Currently, SERDP efforts are winding down on characterization, delineation, and diagnostic procedures, but they are continuing or starting up in thermal treatment, *in situ* distribution of chemical amendments, and fractured rock. ESTCP demonstrations are occurring in biological treatment, monitoring and assessment, thermal treatment, *in situ* chemical oxidation (ISCO), and combining remedies. Research projects are funded through a yearly statement of needs that invites researchers to propose projects to meet some aspect of the need. The proposals are evaluated by a peer review panel and top scorers are funded. ESTCP, on the other hand, has interest areas but no statement of needs. The environmental restoration program currently has over 200 active projects with about 95 percent involving partnerships. The projects run from one to five years.

Leeson said that key areas of interest to the restoration program are an improved understanding of plume response to source depletion; treatment and monitoring approaches for flow-limited portions of source zones; and better understanding and monitoring of vapor transport. She provided an updated FY08 SERDP statement of needs. Future events to look for include a DNAPL side meeting at the SERDP/ESTCP Symposium (December 2007); Training Workshop on DNAPL Frequently Asked Questions (FAQs) and Decision Guide (December 2007); and the publication of a report summarizing DNAPL research and demonstrations (2009).

Questions/Answers

Q: One of the slides indicated that you were looking for better models for decisionmaking. What are you looking for in the next generation of models?

A: We would like to see what the research community comes up with. For example, DNAPL source architecture and its effects on plume flux are not well understood. Without this understanding, modeling the plume over time becomes very difficult.

EMULSIFIED ZERO-VALENT IRON FOR DNAPL SOURCE TREATMENT

Jacqueline Quinn, National Aeronautics and Space Administration (NASA), described work to test and demonstrate emulsified zero-valent iron (EZVI), which was developed by NASA (Attachment C). EZVI is made by combining a food grade surfactant, biodegradable vegetable oil (usually corn oil), and ZVI (nano- or micro-scale). The resulting emulsion is heavier than water, viscous, and hydrophobic. These properties are the same as DNAPLs and may allow the emulsion to follow the same descent pathways as the DNAPL. While ZVI has been used both in walls and solution to treat dissolved phase DNAPL chemicals, its water solution delivery generally prevents its mixing with hydrophobic source zones. Laboratory experiments indicate that the mixing of the emulsion with the source area tends to sequester the NAPL by largely preventing its dissolution into the surrounding water. At same time the ZVI will react with any contaminant molecules it comes in contact with. There is also evidence that the vegetable oil acts as an electron donor to promote bioremediation.

The technology has been demonstrated by NASA at LC 34 (Cape Canaveral, FL) and at the Marine Corps Recruit Depot (Parris Island, SC). At LC 34 there was significant reduction of TCE in target depths and a 56 percent reduction in the mass flux. There were, however, difficulties in controlling the subsurface placement of the EZVI and the need to identify what the contributions of abiotic and biotic processes were in the reduction of the mass flux. At the Parris Island site they tested two methods of delivery—direct and pneumatic using nitrogen as a fracturing tool. EPA took part in the demonstration and used multi-level as well as conventional monitoring wells to sample groundwater for performance monitoring. Continued performance monitoring is proposed through October 2009.

The EZVI technology has been licensed to seven vendors and is used throughout the U.S.

Questions/Answers

Q: Has EZVI been used at sites with mixed DNAPLs?

A: It will degrade anything that ZVI will degrade. They have direct experience with chlorinated ethenes and Freon. While not DNAPLs they have also found that metals with higher electrical potential will plate out on the iron. These include lead, uranium 238, and arsenic.

Q: Is the technology appropriate for polycyclic aromatic hydrocarbons (PAHs).

A: NASA is not aware of its having been used for PAHs.

Q: How many passes are typical with EZVI?
A: Because of the nature of EZVI, one pass is typical unless you miss a contaminant area. The injection method may also have some effect.

Q: Did you observe any rebound?
A: Continued degradation and no rebound were evident in samples after 18 months.

BIODNAPL TREATMENT – FACT OR FANTASY?

David Major, Geosyntec Consultants, said there are a number of ongoing projects that suggest that the cleanup of some source zones by bioremediation is possible (Attachment D). The NAPL dissolves at a fixed rate into the aqueous phase, and the rate of dissolution is driven by the concentration gradient that exists at the water-NAPL interface—the higher the concentration of dissolved NAPL, the slower the dissolution from the source. The greatest mass transfer occurs at the leading edge of the NAPL source because that is where the highest concentration gradient will exist (clean groundwater passing over the surface of the NAPL). This is why the overall length of the NAPL has a strong effect on the average mass transfer across the entire. As the mass dissolves from the leading edge, it is transported and creates higher dissolved concentrations over the remaining NAPL surface. This slows down mass transfer rates further down the NAPL length. Therefore the longer the NAPL pool length, the longer it takes to remove the source by flushing. But many sites don't have continuous pools of NAPL, just stringers, ganglia and blobs that can create an "effective pool length". As the leading edge of these discontinuous NAPL free-phases dissolves, higher dissolved phase concentrations will form over the remaining down gradient NAPLs slowing their dissolution rates.

The goal of bioremediation is to decrease the dissolved phase concentrations near (1) the free-phase NAPL-water interface or (2) in between NAPL phases to create shorter effective pool lengths. The dechlorinating bacteria in the system can survive, if not thrive, in this water. In addition, their destruction of the dissolved chemicals steepens the concentration gradient at the NAPL-water interface and in between the NAPL free-phases and, hence, allows for more rapid dissolution of source chemicals from that area also.

This application of bioremediation to treat a source area was demonstrated at LC 34. A 1.5-gpm system (three injection and three extraction wells) was operated for about four weeks to establish a baseline. Once the baseline was established, a biostimulant (ethanol) was added followed by bioaugmentation with KB-1 and more ethanol. The baseline established what the steady-state dissolution flux was under pumping. After the addition of the ethanol and KB-1, this flux increased by three to five times. The lithology of the site consisted of an upper sand unit, a middle fine-grained unit and a lower sand unit. The system was very successful in treating the upper sand unit and had some success in the fine-grained unit. After 22 months there was no rebound in the area.

Data suggest a two- to 10-fold increase in dissolution is achievable; the technology is most likely suitable for residual or low or highly heterogeneous distribution of pooled DNAPLs; and bioremediation could be coupled with other source treatment technologies.

Questions/Answers

Q: Not in relation to this site, but what were the results of the ISCO/bioremediation study?
A: The amount of permanganate oxide (MnO_2) left in the ground reacted with the electron donor material, which inhibited the bacteria growth.

TCE FATE AND TRANSPORT DETERMINATION AT THE DOE PADUCAH (KY) GASEOUS DIFFUSION PLANT

Steve Hampson, Kentucky Research Consortium for Energy and the Environment (KRCEE), described a site with three (northeast, northwest, and southwest) major TCE plumes (Attachment E). The northwest and southwest plumes also contain technicium 99 (Te^{99}). Flow and transport models (MODFLOW and MODFLOWT) have been used since 1990 to predict TCE fate and transport at the site. Hampson and his project team began in 2006 (under auspices of DOE) to address concerns expressed by regulators and the technical community that attenuation/degradation rates given by the facility through 2005 had not been well supported. DOE's premise was that biodegradation was occurring at the site through an aerobic co-metabolism mechanism rather than anaerobic reduction, which is more common. The project team has set up a series of test and decision rules to show that this process is occurring, and an aerobic degradation investigation, stable carbon isotope evaluation, and abiotic degradation evaluation are scheduled for this summer and fall. The contractor for the site has developed a biological activity probe that will aid in the evaluations.

Questions/Comments

Jim Cummings commented that one of the activities proposed in the project is to map the bacteria to see if there is a sufficient number to have sustainable degradation across the plume area. He said this is not always done and sometimes results in the failure of the project because the micro-organisms may not be uniformly distributed.

Major said that mapping is generally used at a site when there is a high level of uncertainty that needs resolving. For a lot of natural attenuation sites microbe concentrations are taken at two wells and using a groundwater velocity they calculate a rate. He said a more useful number is the activity rate at a given well rather than a bacteria count. Activity rates can be used to estimate overall attenuation capacity. Also carbon isotope ratios within a plume can be used to estimate what type of degradation is occurring.

Beth Moore added that SERDP/ESTCP has funded the development of a protocol for the enzyme activity probes that are being used at DOE's Paducah Gaseous Diffusion Plant site (KY). The activity probe was key in obtaining approval for MNA as part of the Record of Decision (ROD) in Test Area North.

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NAVY DNAPL TREATMENT STORIES

Kings Bay Naval Submarine Base

Francis Chapelle, U.S. Geological Survey (USGS), presented a history of remediation activities at the Kings Bay Naval Submarine Base in Georgia that utilized a treatment train including in situ chemical oxidation (Fenton's reagent), enhanced reductive dechlorination, and MNA (Attachment F). The site is a former municipal landfill that had 55-gallon barrels of PCE disposed in it. The original groundwater remedy included a pump-and-treat to contain the plume at the Navy property boundary. A study of the site showed that intrinsic biodegradation of PCE and TCE to ethylene was occurring; however, the attenuation capacity was not sufficient to complete reduction before the plume left the property boundary and flowed under a residential area. Direct push equipment with a field gas chromatograph was used in a direction perpendicular to the ground flow to obtain a profile of PCE and TCE concentrations. The core of the plume was then tracked back into the landfill area where the areal extent of the source area was delineated. Fenton's reagent was chosen to treat the source zone and the injections occurred in 1998.

By 2006, concentrations of contaminants had decreased by an order of magnitude, and contaminant flux values were down by two orders of magnitude. The difference between treated water and untreated water could be discerned by the concentrations of sulfate, which was injected as part of the Fenton's reagent treatment process. The natural attenuation process is keeping the plume concentrations of vinyl chloride below 30 µg/L at the downgradient plume boundary. Concentrations of chlorinated ethenes remain below 10 µg/L in the former source area. Kings Bay is an example of how combining source area removal with MNA can be an effective remediation strategy when hydrologic conditions are favorable.

Naval Air Station Pensacola

Mike Singletary, Naval Facilities Engineering Command Southeast (NAVFAC SE), discussed use of a treatment train at Naval Air Station Pensacola in Florida (Attachment G) consisting of in situ chemical oxidation and MNA. The site geology consists of a 40-ft-thick fine sand sequence followed by a five-ft-thick silty sand underlain by a silty clay. The surficial aquifer discharges into Pensacola Bay. The contamination, including chlorinated solvents, chlorinated benzenes and metals, was caused by the disposal of waste water treatment plant sludges containing industrial wastes. A pump-and-treat system was operational at the site from the mid 1980s to the mid 1990s. The RCRA Corrective Action Permit was modified in the late 1990s to replace the pump & treat system remedy with source reduction and MNA.

Natural attenuation was actively occurring at the site prior to treatment with chemical oxidation, and the idea was to reduce the source zone concentrations and to allow MNA to be more efficient. A Fenton's reagent solution (50 percent H_2O_2) was pressure injected between 35 and 40 ft below ground surface (bgs) in December 1998 and again in May 1999. While contamination levels were low following the treatment, there was TCE rebound after about two years. In the fall of 2004, a Triad-type investigation employing a membrane interface probe (MIP) was conducted at 35 locations. The MIP investigation showed no residual in the soil column down to the silty sand unit at 40 to 45 feet below ground surface where considerable contamination was found. The MIP investigation also indicated that the source zone was larger than originally believed and, as a result, not all of it had been treated. A new treatment approach using emulsified vegetable oil is currently being planned. NAS Pensacola is an example of how the effectiveness of source zone treatment can be limited if site hydrologic conditions and/or site characterization are not optimal.

Questions/Comments

Comment: At any site there is a need to carefully characterize the source in order to evaluate whether it can be addressed before conducting any remedial activities. With direct push tools this is much easier and less expensive to do than in the past. There is a high probability that older sites have insufficient characterization. Also the failure of an *in situ* remedy may be because of poor characterization, not because it was an improper choice.

Q: Carol Dona (USACE) asked what effect the chemical oxidation had on the microbes.

A: At Kings Bay, cores were tested for microbial activity both before and after treatment. Before the treatment activity was good. After the treatment there was no activity, but when checked 6 months later, the population had rebounded. Carbon may have to be added to the subsurface to ensure rebound.

COMBINING REMEDIES FOR NAPL SITE REMEDIATION

Jim Cummings said remedies can be combined spatially by treating different zones with different technologies or temporally by adjusting/changing technologies at appropriate points when their effectiveness has diminished (Attachment H). Some technologies such as chemical oxidation might be used to prime the subsurface for subsequent bioremediation (e.g., Kings Bay). There are many technologies that can be effectively combined (e.g., surfactant/cosolvent and bioremediation, soil vapor extraction and bioremediation, etc.) The main concept is to carefully evaluate the problem from all perspectives and not use a conventional feasibility study based on operable units that generally select one technology for addressing the whole of the current situation. Cummings suggested that a way to promote smart treatment is through flexible RODs. One area needing more research is how to determine the appropriate time to transition from one technology to another.

Electrical resistance heating was used at the Charleston Naval Facility for a PCE problem. The initial results indicated 79 percent reduction in dissolved phase contaminants. Subsequent bioremediation reduced the size of the plume.

Persulfate can be activated in a number of ways and one of them is with heat. Steam activated persulfate cleanups have been shown to be very cost effective.

Surfactants have been used to address DNAPL contamination but are not as popular as other methods. Their main drawback is that, in the absence of a nearby confining layer, they can mobilize a DNAPL and cause it to sink deeper into the aquifer before it can be recovered. Surfactants are, however, doing well with LNAPLs and can be combined with chemical oxidation as a polishing step if the cleanup goal is stringent.

Enhanced reductive dechlorination is accomplished by adding an electron donor to the subsurface (such as a vegetable oil) and the effectiveness of donor material is site specific.

Some of the issues involved with combining remedies are the impact on microbes, effects of oxidants on thermal system components (potential corrosion), and whether the costs of the treatments will be synergistic or additive. Some recently combined-remedy RODs have been written for the Pemaco Maywood (CA) site (solvents), Brunswick Wood (GA), and Grants Chlorinated Solvents (NM) site.

Whether single or combined technologies are used, much more attention needs to be paid to what is happening in the reaction zone and how it can be measured. Flexible, adaptive implementation is a crucial component of combining remedies. For example, when the vendor noticed that what the characterization had said about contaminant distribution was not quite what he was seeing while installing heater wells at a site. The heater wells were emplaced on much tighter centers than the characterization boreholes, and hence, he was able to determine that his wells had to be deeper in places than originally assumed. Equipment emplacement can be considered a polishing step to characterization.

LESSONS LEARNED FROM IN SITU THERMAL TREATMENT OF SOURCE ZONES FT LEWIS, WASHINGTON

Kira Lynch (USACE) reported on the approach and lessons learned from the resistive heating application at the East Gate Disposal Site at Ft. Lewis (Attachment I). The TCE plume emanating from the source is 18,000 ft long and affects both the upper and lower aquifers. There is a groundwater pump-and-treat system operating at the site for hydraulic control. Site characterization efforts identified three target areas for electrical resistive heating after drum excavation and removal. The goal of the heating was to maximize NAPL removal. In a project like this, it is important to set criteria that balance the cost of remediation with the potential for adequate mass removal. The criteria should be realistic and measurable.

The approach used an adaptive site management style that allowed for the flexibility to expand or contract treatment zones and have an open-ended treatment time. A performance-based design/build contract was let, and it facilitated system modification during construction. A Web-based communication system was established to display data and aid in communication among project stakeholders. The flexibility in the contract on performance goals was important when it was discovered that several strata in the subsurface were very permeable with high groundwater velocities that prevented them from reaching the target 90^{o} to 100^{o} C heating goal. The performance goal in the contract was altered to exclude these areas from the requirement.

Groundwater temperatures were monitored in the source zone and downgradient. The elevated temperatures downgradient indicated that groundwater flow was not under control. The change in concentrations of TCE and dichloroethylene (DCE) in the downgradient area also indicated that a rise in water temperature was facilitating biodegradation. The project initially used remedial investigation data to estimate the thickness of the NAPL. This thickness was based on one borehole per 4,000 square ft. The estimate was revised downward by 30 percent using data gathered in the placement of the heater electrodes, which had one borehole per 250 square ft.

The treatment greatly reduced contaminant levels in the groundwater. Average soil concentrations of TCE in Area 1 were less than 1,261 ppb and in Area 2 less than 544 ppb. Measurement of chloride ion also suggests significant *in situ* destruction of contaminants, and rebound is not expected.

NATURAL ATTENUATION SYSTEM (NAS) – SOFTWARE FOR ASSESSING COMBINING SOURCE AREA REMEDIATION WITH NATURAL ATTENUATION

Mark Widdowson, Virginia Tech, said the NAS software was developed as a computational tool for evaluating the effect of source zone remediation based on plume size and strength reduction and on the time of remediation (Attachment J). It is a screening tool that can be used in a predictive capacity and for assessing work in progress. It uses source size and shape, local hydrogeology, and local attenuation capacity to estimate with a given flux how large the plume will be and how long it will take for the source to dissipate. The Kings Bay Naval Submarine Base site provided an example of how the tool can be used. At the beginning source strength, the point of stabilization was well beyond the point of compliance. The tool can provide an estimate of how much the source needs to be reduced to put the point of stabilization at the point of compliance.

For source depletion, NAS employs a numerical source zone model using SEAM3D, a reactive transport model used to simulate complex biodegradation problems involving multiple substrates and multiple electron acceptors. This code is capable of handling essentially pure chemical masses as well as mixtures. The user has to supply estimates of the total mass, composition, geometry, and mass flux. As post-remediation monitoring data is gathered, it can be entered into to the model to compare predicted-versus-observed trends. Using the new data, the model will revise its concentration-versus-time curves to provide a more reliable estimate, since most of the beginning input data will have some degree of uncertainty.

ESTCP funded the testing of the tool at eight chlorinated solvent sites. The sites were chosen to provide a range of conditions and source control options. It was evaluated by comparing results to long-term monitoring data (> eight year). The conclusions of the testing were that NAS provides a reliable framework for implementing analytical and numerical solutions for applying source zone remediation with MNA; was effective in predicting the time of stabilization; and was effective in capturing depletion time trends of a multi-component DNAPL. Cummings invited meeting participants to attend NAS training the following morning.

MEETING WRAP-UP

Norm Niedergang thanked everyone for attending.

Kingscott reported that balloting for the next FRTR meeting topic indicated that *in situ* bioremediation of radionuclides and metals was of most interest to member-agencies. Other topics receiving votes were optimization, remediation of sediments, and vapor intrusion. Beth Moore stated that the radionuclide and metals topics should encompass both *in situ* bioremediation and natural attenuation and that the presentations should not focus on just metals or just radionuclides. Kingscott asked DOE and NRC representatives to help him in identifying and arranging for appropriate speakers on this topic.

Moore raised an issue concerning the coming publication in the fall of the EPA Office of Research and Develop (GWERD Ada) guidance document on monitored natural attenuation of metals which will be followed by a subsequent volume on radionuclides. She stated that the guidance is welcome, but EPA has no accompanying policy on the guidance. She asked that a short policy discussion on regulatory cleanup levels/framework to be included in the Fall 2007 FRTR meeting agenda.

Neidergang invited the members to consider having their organizations host the next FRTR meeting in the Fall (usually December). If no other member-agency volunteers, EPA will host it again at Potomac Yards.

The meeting was adjourned.

ATTACHMENTS
A list of meeting participants appears at the end of this summary.

A. **DNAPL Overview – Progress and Challenges**
B. **SERDP/ESTCP DNAPL-Related R&D/Demonstration Projects**
C. **Emulsified Zero-Valent Iron for DNAPL Source Treatment**
D. **BioDNAPL Treatment – Fact or Fantasy?**
E. **TCE Fate and Transport Determination at the DOE Paducah (KY) Gaseous Diffusion Plant**
F. **Naval Submarine Base Kings Bay Georgia**
G. **Naval Air Station Pensacola Florida**
H. **Combined Remedies/Treatment Trains for NAPL Site Remediation**
I. **Lessons Learned from *In Situ* Thermal Treatment of Source Zones – Ft Lewis, Washington**
J. **Natural Attenuation System (NAS) – Software for Assessing Combining Source Area Remediation with Natural Attenuation**