

FEDERAL REMEDIATION TECHNOLOGIES ROUNDTABLE MEETING
Arlington, Virginia
June 9, 2004

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FEDERAL REMEDIATION TECHNOLOGIES ROUNDTABLE MEETING
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ACTION ITEMS

- ▶ FRTR members are to consider and discuss the problem of how to disseminate the cost and performance case studies in future years. With the addition of the most recent updates, the complete set of case studies fills a single CD to capacity, which means future updates will not fit. Please forward any suggestions to John Kingscott (EPA/OSTRI).
- ▶ To promote greater distribution of FRTR cost and performance materials, members who hear of or plan to attend meetings with a remediation track should notify John Kingscott via email, so he can plan to supply appropriate materials.
- ▶ Members will consider supplying information on future agency remediation conferences for posting to the FRTR website and send their thoughts to Greg Mellema (USACE) on their willingness. Mellema will pursue the development of an area on the FRTR web site where members can post information about future remediation meetings. After the Corps creates the area, the FRTR Chair will notify members as to its availability and use.
- ▶ John Gillespie (USAF) will identify the Air Force point of contact for decision support tools (DSTs) to Carlos Pachon (EPA/OSTRI).
- ▶ Rajat Ghosh (RETEC/SERDP) will send to Carlos Pachon a list of decision support tools emerging from SERDP and ESTCP for inclusion in the DST matrix and identify the appropriate contacts.
- ▶ Thomas Nicholson (NRC) will send Carlos Pachon a list of DSTs that are being developed within his agency with appropriate contacts.

WELCOME/OPENING REMARKS

Walt Kovalick (U.S. EPA/OSRTI) welcomed the attendees to the Federal Remediation Technologies Roundtable (FRTR) meeting and had participants introduce themselves and provided an overview of the agenda. He noted that the Roundtable had convened twice each year since December 1990.

Kovalick noted the imminence of “Accelerating Site Closeout, Improving Performance and Reducing Costs Through Optimization,” to be held June 15-17 in Dallas, Texas. Participating organizations include the FRTR, EPA, DOE, and Interstate Technology and Regulatory Council (ITRC), and the Navy, Air Force, Army Corps of Engineers, Defense Logistics Agency, and Strategic Environmental Research and Development Program/Environmental Security Technology Certification Program (SERDP/ESTCP). The conference has generated so much interest that the meeting programmers were unable to find room on the schedule for 50 submitted posters. More than 500 people have registered, almost double the turnout anticipated.

STATUS REPORT: TECHNOLOGY COST AND PERFORMANCE ACTIVITIES

John Kingscott (EPA/OSTRI) updated Roundtable members on the status of the FRTR Technology Cost and Performance case study database (www.frtr.gov/costperf.htm) and discussed its expanding coverage (See Attachment A). The meeting handouts included a pre-publication copy of the new fact sheet about the cost and performance case studies. Kingscott asked the attendees to look it over and get back to him with any suggestions within the next few days, as it is about to become final.

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The effort to collect and disseminate cost and performance information on remedial technologies started almost 10 years with the development of case study reports. Case studies of remediation techniques were followed by studies of site characterization and monitoring, then by broad technology analysis at multiple sites, and then by long-term management and optimization studies. New reports generally are added each spring, and this year's additions boost the total number of FRTR resources to over 600 reports in the following four focus areas:

Remediation technology cost and performance case studies:	361
Site characterization and monitoring reports:	145
Long-term monitoring/optimization case study reports:	73
Remediation technology assessment reports:	54

In addition to collecting new case studies and producing the fact sheet, Kingscott has overseen the development of a new searchable database for the long-term monitoring/optimization case studies, updates of all areas with recent reports, compilation of the eighth abstract report and CD-ROM (due out this summer), and enhancement of searching capability by date in the remediation case studies database.

- ▶ The 73 case studies of long-term monitoring/optimization case studies describe systems that are in the ground and operating. Systems that exist only as models or designs are not included. Kingscott described the parameters under which the new database can be searched and profiled the types of systems contained in it. Sixty-three of the studies involve pump-and-treat systems, which may be used concurrently with PRBs, air sparging, or other cleanup technologies.
- ▶ Nineteen new treatment technology case studies are being added for Spring 2004. Seven are from EPA, six from the Navy, four from the states, and one each from DOE and ESTCP.
- ▶ Some of the 24 new site characterization and monitoring case studies are older studies of explosives characterization provided by the Army.
- ▶ Kingscott remarked that two of the 54 new remediation technology assessment reports may be of particular interest because they address the long-term viability of permeable reactive barrier walls.

The next steps are to send out the new fact sheet and CD-ROM to the people on the Roundtable mailing list and to consider the future role and scope of the CD-ROM. Kingscott said that the current capacity of CD-ROM technology has been reached and EPA is considering alternatives. He asked the group if the CDs are still considered to be useful and needed in light of the advances in search capability on the FRTR web site. Several people hurried to assure him that the CDs are still in demand and are particularly useful when access to the Internet is unavailable or slow. One member suggested switching to DVD-ROM because of greater storage capacity and increasingly reasonable cost, but others feared that many end-users lack access to the technology to use this more sophisticated product. Another member suggested dividing the resources into technology-specific CDs with appropriate labeling to highlight the focus area. Someone else asked if some of the case studies could be retired or archived. Kingscott responded that a few of the technologies are represented only by reports from the mid-1990s, and if cases were retired by date, these technologies might have no presence at all on the CD. Kingscott urged those assembled to consider the problem and send their suggestions to the appropriate agency contact.

When asked if the cases in the optimization database had any overlap with the Kathy Yager/ITRC optimization effort, Kingscott replied that the case studies in the Yager/ITRC effort most likely have been captured in the FRTR database. He noted that the ITRC report will not describe how to optimize, but rather how to review an optimization study or effort.

Linda Fiedler (U.S. EPA/OSTRI) suggested that opportunities for distributing the FRTR CDs and other products could be increased if OSTRI were better informed of upcoming conferences. Some environmental meetings with a remediation theme put out little in the way of advance publicity or target these efforts so selectively that other interested parties don't hear about a meeting until after the fact—for example, the Navy meeting in Port Hueneme that was held around Valentine's Day. Greater input is needed from FRTR members concerning such meetings. Walt Kovalick suggested that members who hear of or plan to attend meetings with a remediation track (but that are not likely to be widely publicized) notify John Kingscott via email so he can supply appropriate materials. In addition, if members agreed to supply information on agency remediation conferences, Greg Mellema with the Corps could post this information to the FRTR website.

UPCOMING NRC STUDY ON ENGINEERED BARRIERS

Kelly Madalinski (EPA/OSTRI) stood in for Anthony de Souza of the National Research Council (NRC) to update the status of the upcoming NRC study on engineered barriers (See Attachment B). The purpose of the study is to assess the performance of containment systems (liners, caps, and vertical barrier walls) and develop and describe an improved framework for assessing their performance. The genesis of the study was from a NRC sponsored two-day workshop on Engineered Containment Systems in July 2001. At the workshop, participants identified key questions that could be addressed in a NRC study. Participants included academia, industry, and federal agencies such as the National Science Foundation, Nuclear Regulatory Commission, EPA, and DOE. From the workshop, a draft prospectus was developed, entitled *Assessing the Performance of Surface and Subsurface Engineered Barriers*. Current sponsors include Environmental Protection Agency, Nuclear Regulatory Commission, and National Science Foundation

The study is to encompass three specific tasks:

- Describe current and emerging containment systems.
 - How is their performance defined?
 - For how long are they effective, and what factors affect their lifetimes?
- Assess the current state of science and engineering for risk assessment methodology, system installation, performance monitoring, and sustainability.
- Identify data gaps and long-term research needs.
-

The presentation includes illustrations of the typical components of a closed double-lined landfill and a vertical barrier, and the status of engineered barriers with regard to type of technology, years of experience, status of technology development, and level of field performance characterization. Contact information is provided for participating agencies.

Because of the relevance to each of the member agencies, Madalinski encouraged members to actively participate in the study – either being a sponsor or providing their perspective and experience on the topic

Beth Moore (DOE) volunteered that field information is available from a study done at the Nevada Test Site on the consequences of subsidence at a disposal site. Also, caps are being installed at Hanford, and contacts can be provided for that work. And the Environmental Management Science Program is sponsoring a burial project to study the effects of corrosion. Madalinski suggested that she forward this information to Anne Linn (NRC) at alinn@nas.edu or 202-334-2744.

CREATION OF TRIAD PROJECT PROFILES DATABASE AND TRIAD UPDATE

Linda Fiedler unveiled the latest Triad development, the new on-line Triad Resource Center, which is co-sponsored and hosted by Argonne National Laboratory at www.triadcentral.org (See Attachment C). The site is up and populated, though content for some of the pages is still pending.

A recent document, *Technical and Regulatory Guidance for the Triad Approach: A New Paradigm for Environmental Project Management* (December 2003), is available from the ITRC (www.itrcweb.org). The document describes the Triad process, explains measurement options, discusses regulatory barriers and proposed solutions, and offers several case studies. The text will be used for training.

The five Triad training opportunities offered in the first half of 2004 have had good attendance, and several more events are scheduled for the latter half of the year. Walt Kovalick remarked that some of the agencies interested in 201 (advanced) Triad training were flustered that they didn't have enough staff with 101 (basic) training to take advantage of the higher-level training. Given the level of interest, more 201 training may be offered in November.

Fiedler reminded FRTR members that EPA provides Triad technical assistance and support to federal managers. She also identified technical assistance contacts and sites at which Triad has been or will be used.

The searchable database of Triad or Triad-like projects currently under development will highlight the technologies used, the time and money saved, and stakeholder relationships and participation. The aim is to provide as much information as possible in the way of procurement documents and work plans for each project. Software development and the incorporation of 10 to 15 initial projects is expected to be completed this summer.

A suggestion was that we be sure to include Triad projects where they belong in the FRTR case studies and databases. Fiedler said that TIFSD can work to make this happen to the extent possible. There may not always be full case studies of the projects, but just a "profile." We'll have to see if that is sufficient.

DECISION SUPPORT TOOLS: STATUS AND PATH FORWARD

Carlos Pachon (EPA/OSTRI) updated the assembly on the decision support tools (DSTs) project via speaker-phone. Decision support is considered an enabling tool for the management of a site investigation under the Triad approach (See Attachment D). Pachon said that contractor support has been lined up for further development of the draft DST matrix presented at the December 2003 meeting. The 20 parameters in the matrix allow users to determine the DSTs potentially useful for a particular site or situation.

Pachon is the DST point of contact within EPA, which will provide contractor support, prepare an inventory of tools used in-house (e.g., a PDA Scribe for importing information from the field into a DST), and compile information on user experiences. DOE has funded the preparation of the first draft and will provide additional DST experiences, with Terry Sullivan as the contact. Greg Mellema will provide input from the Army Corps of Engineers. The Air Force will take part as well, and the contact has been tentatively identified as Jesse Perez; John Gillespie (USAF) volunteered to follow up on the determination of point of contact. Production of the matrix is targeted for December 2004.

Assistance from FRTR members has added value to this work, and Pachon hopes for further input from them on the structure and criteria used in the draft matrix, as well as independent verification and validation of known systems. Production of the matrix is targeted for December 2004.

Beth Moore and Rajat Ghosh (RETEC/SERDP) spoke up to urge further input from the other agencies. Tools are emerging from SERDP and ESTCP that should be included in the matrix, and Ghosh will email contact information for these new products to Pachon. Thomas Nicholson (NRC) also volunteered to send a list of contacts for tools that are being developed within his agency.

FRTR FY 04 BUDGET

The meeting handout package included a table identifying interagency funding commitments to FRTR projects from 1998 through 2004 (See Attachment E). Walt Kovalick reviewed this information and asked participants to consider funding possibilities in their agencies. He also noted several new projects that FRTR may be able to undertake if sufficient funding is forthcoming, including:

- 1) Study on performance of diffusion samplers for sediments
- 2) FRTR SITE characterization training
- 3) Modernization of the FRTR Characterization Matrix
- 4) DNAPL technology maturation project
- 5) Support for State of Practice documents
- 6) Operate cost and performance web site and compile next round of case studies

NEXT MEETING TOPICS

Kovalick indicated that this meeting's technical focus area, Environmental Nanotechnologies for Site Cleanup, has generated so much interest that it will be followed at the next meeting by Phase II: Nanotechnologies for Monitoring and Measurement.

ENVIRONMENTAL NANOTECHNOLOGIES FOR SITE CLEANUP

PROGRAM DIRECTION

Nanotechnology at EPA: Focus on Remediation

Stephen Lingle (EPA/ORD/NCER) presented an overview of EPA spending on nanotechnology research and provided examples of the types of treatment, remediation, and monitoring projects being funded under the Science To Achieve Results (STAR) and Small Business Innovation Research (SBIR) grant programs (See Attachment F). He highlighted two projects for reducing chlorinated compounds in groundwater: (1) nanoscale iron coupled with palladium, and (2) protein-encapsulated, nano-sized iron oxide particles developed as catalysts. The National Center for Environmental Research web site (www.epa.gov/ncer) contains abstracts and progress/final summaries for all funded projects. A search under "nanotechnology" at last count yielded 52 projects. NCER currently is focusing on nanotechnology risk assessment, specifically the health and environmental effects of exposure. Lingle reminded the audience that EPA is a member of the National Nanotechnology Initiative, a federal cross-agency framework that recognizes nanotechnology as a top research priority. For more information on the Initiative, visit www.nano.gov.

Environmental Nanoscale Research in the DOE Office of Science

Greg Wilson (EPA/OSTRI) stepped as the presentation pinch-hitter for Teresa Fryberger (DOE). DOE has issued two solicitations under its Office of Basic Energy Science (BES) and Office of Biological and Environmental Research (BER). BES is the major source of funding for nanoscale research in DOE's Office of Science and is supporting the construction of five Nanoscale Research Centers (See Attachment G). BES supports bio/environmental research, some of which has nano-components.

DOE is sponsoring a nanosummit, "Nanoscale Science and Our Energy Future," at the Marriott Wardman Park in Washington, DC, on June 23-24 (<https://public.ornl.gov/conf/nanosummit2004/>). The purpose of the nanosummit is to bring together policymakers and the scientific community to share information on emerging research opportunities and priorities in nanoscale science and technology for our energy future. The program will address topics of major interest to DOE: nanoscale science and the hydrogen economy; ethical, social, and environmental considerations; nanoscale science and energy efficiency and renewable energy; and nanoscale science and energy supply.

SERDP/ESTCP-Funded Research and Technology

Rajat Ghosh (The RETEC Group, Inc.) briefly discussed two projects related to the application of nanoscale zero-valent iron (ZVI) for treatment of DNAPL source zones. The first project involves the addition of palladium to produce bimetallic nanoscale ZVI. Palladium enhancement of the performance of the iron is being investigated in column studies to examine reaction rates and transport. This effort is still in bench-scale mode, but the work is likely to be moved to the field in 2005, perhaps at Vandenberg Air Force Base. The second project will examine the effect of applications of emulsified nanoscale ZVI at two DNAPL sites. Various methods of ZVI delivery will be tested to determine which method produces the best results. Ghosh also mentioned a non-nanotechnology project to explore the application of a ZVI reactive barrier for treatment of dissolved TNT and RDX downgradient of the source zone at the Cornhusker Army Ammunition Plant, Grand Island, Nebraska. He said that SERDP plans to award more nanotechnology-based projects this year, perhaps oriented more toward basic science than the two already described. Nanotechnology is not a 'named' area in SERDP research; it presently falls under the groundwater umbrella.

Walt Kovalick asked whether all the nanotechnology projects were focused on groundwater. Greg Wilson responded that though most of the remediation projects discussed at this meeting involve groundwater, nanosensors are more varied and are being developed for air, water, and soil. Ghosh said that the effect of nano-iron on the soil column also is under study. Jacqueline Quinn (NASA) commented that in Japan, iron nanoparticles are being incorporated into the plastic used to make plastic bags. About 75 percent of waste in Japan is incinerated, and it's been observed that the added nano-iron seems to help reduce dioxins in incineration chemistry.

EMULSIFIED ZERO-VALENT IRON TREATMENT of CHLORINATED SOLVENT DNAPL SOURCE AREAS

Jacqueline Quinn reported the results of an application of emulsified zero-valent iron (EZVI) to a TCE source zone at site LC34 at Cape Canaveral (See Attachment H). The emulsion technology was developed to make ZVI more "friendly" to organic contaminants. An exterior vegetable-oil membrane makes the droplet behave like a DNAPL, which makes it easier for DNAPL to contact the iron core.

The presence of the oil also has a biological component that adds a polishing element to the remediation process. An EZVI technology evaluation demonstration was conducted at NASA LC34 inside a building, and the following injection techniques were field-tested: pressure pulsing, pneumatic fracturing, hydraulic fracturing, and direct injection. Each injection technology vendor was given 100 gallons of EZVI made with nanoscale iron and told the desired region of influence (ROI) for each application. Immediately following injection, soil cores and FLUTe® liners were used to evaluate where and how far the EZVI was distributed. The iron compound was black, so visual confirmation was possible.

Pneumatic injection of EZVI in sandy soils looks promising. In sandy soils, it is able to disperse EZVI evenly and at target depths and achieve a sufficient ROI. Hydraulic fracturing of EZVI does not deform emulsion droplets and may have application in consolidated sediments or tighter soils. Pressure pulsing did not overcome soil heterogeneities enough for the highly viscous EZVI to achieve the desired ROI. The approach may be suitable for aqueous-phase materials or pure vegetable oil. Direct push has application to small sites where the rig can make many injections of EZVI in a single day, making it very cost-competitive over injection technologies that seek larger ROIs. NASA holds the patent for the direct push technology, and it is available for all U.S. government agencies to use royalty-free.

For the future, more research is needed to determine the percentage of degradation due to ZVI and the percentage due to biodegradation. EZVI deployment in two pilot test areas within a DNAPL source zone will be pursued (one possibly at Camp Lejeune) using the two most promising EZVI injection technologies with the objective of providing cost and performance data.

Nanoiron used to be quite expensive, but now it costs about \$20/gallon. For treatment, figure roughly eight pounds of emulsion for each pound of TCE.

Question: What does the NASA patent cover?

Answer: The U.S. Patent and Trademark Office split the patent in two, so we were granted the first one for making EZVI in December 2003, and the second one for deploying a 'transition metal' went back into the loop. It will probably be approved in about two years.

Question: Has EZVI been tested on other contaminants?

Answer: In the field, only on TCE, but in the lab it has worked on Freon, metals, PCBs, TNT, RDX, and other chlorinated solvents.

Question: Has the technology received much testing with regard to depth of emplacement and temperature?

Answer: Not much, so far. We plan to test it in a fractured bedrock site. It has been tested following steam injection and maintained its stability at 200° Fahrenheit. Testing at cold temperatures has been extremely limited.

Question: TNT is very different from DNAPL. Does EZVI really work for both?

Answer: It works on both free and dissolved phase DNAPL. For a period of time, it prefers DNAPL, but when the emulsion has been consumed, the iron works on any contaminant it contacts.

NANOTECHNOLOGIES for SITE REMEDIATION

Wei-xian Zhang (Lehigh University) presented a brief background on nanotechnology in general (See Attachment I) and mentioned one of his articles, “Environmental Technologies at the Nanoscale,” which is available online at www.lehigh.edu/nano/ZhangESTFeature.pdf. His presentation also touched on some recent work with nanosensors, nano catalysts and reactants, nanosorbents, and potential problems resulting from nanoparticle pollution of the environment.

Zhang began working with nanoparticles as super-reactants in 1995 and investigating the use of nanoscale iron particles for remediation. He discovered that nanoscale Fe can treat almost any chlorinated compound. He has tested more than 70 compounds so far. For a field demonstration, he applied about 10 kilos of nano Fe at a TCE site in North Carolina. The application used the simplest installation techniques: braced excavation, a slurry wall, continuous trenching, and a vibrating beam. There was no forced injection; the iron was dumped in and gravity took it down.

Nanoparticle remediation is effective because the surface area is what matters, not the mass of the particles. That’s why porous nanoparticles are so important—because presenting surfaces both externally and internally makes their total surface area tremendously greater. A 0.4 mm hollow sphere of iron has a surface area 1500 times larger than the surface area of a 0.4 mm solid sphere. But porous iron is not yet commercially available; if you want it, you have to make it.

Question: With regard to increasing the surface area and minimizing gravitational settling, will this porous lightness affect delivery? Will it present an impediment?

Answer: In most cases, you want mobility to increase the ROI, but not always. Big particles can move inches or feet. In water, light particles tend not to move very far because of coagulation.

Question: Have you done comparable simulations of transport?

Answer: We’ve done sandbox simulations that were mostly determined by groundwater chemistry, surface charge, and pH.

ENHANCED REDUCTIVE DECHLORINATION through BIOLOGICAL INTERACTION with ZERO-VALENT IRON

Brian Wrenn (Washington University) began by reviewing the basic biological reduction process for PCE and comparing the biological reduction process with reductive dechlorination by ZVI (See Attachment J). With the context established, Wrenn then discussed the breakdown of PCE brought about through microbial interactions with emulsified ZVI. The contaminant needs to be in an aqueous phase for the biological effects to take place; the process doesn’t work on pure DNAPL. He summarized the following conclusions.

- Microbial activity can interact synergistically with ZVI to enhance degradation rates of chlorinated aliphatic hydrocarbons (CAHs) in groundwater in several ways:
 - Hydrogen produced by anaerobic corrosion of Fe(0) can support microbial reductive dechlorination.
 - Fe(III)-reducing bacteria can reduce surface ferric oxides to generate sorbed Fe(II), which can reductively dechlorinate CAHs.
- Microbial metabolism of the vegetable-oil coat of emulsified ZVI can support reductive dechlorination of chlorinated solvents in groundwater because:

- The vegetable-oil shell prevents direct interactions of microorganisms with zero-valent iron particles.
- Anaerobic biodegradation of vegetable-oil fatty acids results in localized production of hydrogen, which can support biological reductive dechlorination of CAHs.
- Acetate can serve as a distant hydrogen source if iron-reducing bacteria are present.

STATE of SERDP/ESTCP-FUNDED RESEARCH AND TECHNOLOGY

Rajat Ghosh indicated that the SERDP/ESTCP bimetallic nanoscale ZVI project is testing the efficacy of ball-milled nanoscale bimetallic ZVI to treat chlorinated hydrocarbon source zones at the bench scale, investigating colloid longevity issues in batch tests, and evaluating transport properties in one dimensional column tests (See Attachment K). Also, methods of producing the bimetallic nanoscale injectable ZVI are being explored (ball milling and chemical precipitation), and the resulting products are being tested to see what effect the different production processes have on the iron's efficacy and reactive longevity. The ball-milled Fe colloid at 100-600 nm has achieved good reactivity, with 95% TCE removal in batch and column studies. The technology looks promising (injectable slurry, high reactivity), though it is not mature enough to warrant a field demonstration at this point.

The emulsified nanoscale ZVI project is working to improve the EZVI delivery process by examining and comparing the following methods of delivery: hydraulic fracturing, pneumatic fracturing, pressure pulse technology (PPT), and direct injection. The investigators also are evaluating contributions of the abiotic (ZVI-mediated) and biotic (oil- and surfactant-mediated) processes on organics degradation and demonstrating and validating the technology for widespread use in DNAPL source zones at DoD sites. The emulsified nanoscale ZVI (10-100 nm) is produced first by milling, followed by hydrogen reduction of iron oxides (the Toda Process). When the nanoscale ZVI has been obtained, emulsification is performed with food-grade surfactant, biodegradable vegetable oil, water, and nanoscale ZVI. EZVI technology has been tested at the NASA LC34 Site, and an ESTCP field demonstration will be underway in September of 2004. The future of this technology looks promising because it creates reducing conditions suitable for natural attenuation or to enhance bioremediation for "polishing." Removal or reduction of source areas allows natural attenuation or enhanced bioremediation to provide a complete remedy. Optimum reagent delivery at the source zone and the unit cost of EZVI will control the cost and performance of this technology.

Ghosh discussed some areas of concern with nanoscale ZVI technologies with regard to longevity issues, transport issues in the subsurface, reagent delivery techniques, and production costs—from an economic standpoint, production costs need to be below \$5/lb.

Walt Kovalick commented that ZVI has been used in the past for dissolved phase plumes, but now is being applied to source term remediation, which is very exciting. The cost of iron could be trivial for a source-term control project versus a plume project. He suggested that the cost comparison should be against the appropriate base project, i.e., dissolved phase ZVI costs against those for pump and treat, and source-term ZVI against, for example, in situ oxidation. Ghosh replied that at present, costs are mostly lab-based, but in the field, they will be comparing the costs of the test system against the costs of other APPROPRIATE systems.

NANOSCALE PARTICLE TREATMENT of GROUNDWATER

Richard Mach (NAVFAC) described the application of elemental iron to remediate groundwater at three sites (See Attachment L). All the applications involved nano- or micro-scale iron. After \$1 million had been spent on monitored natural attenuation (MNA) of TCE contamination at Naval Air Engineering Station Lakehurst, New Jersey, the regulators suggested moving to a more aggressive approach. Nanoscale iron with a palladium catalyst performed so well in a 2001-2002 field demonstration that the ROD was amended with an Explanation of Significant Differences. The iron was injected by Geoprobe, and TCE levels in the treatment zone decreased by 50 percent on the first pass. Full-scale treatment of two plumes took place in 2003 and 2004.

With the Naval Air Station Jacksonville site in Florida, the Navy didn't pursue the usual R&D process of looking for a site. Instead, RPMs were asked to come forward and propose specific technologies to solve specific problems. The source area for groundwater contamination by various chlorinated solvents was addressed with nanoscale iron with a palladium catalyst using two injection methods: strategic DPT injection and a recirculation process. They haven't yet determined which injection method works better. Sampling indicates good remediation results so far, but the data are still being interpreted.

Microscale ZVI was applied via pneumatic fracturing/injection to reduce TCE in groundwater at Hunter's Point Shipyard in San Francisco, California. TCE was present in the groundwater at up to 88mg/L (not 88 µg/L as appears on slide 16 of the presentation), and the injection removed 99.1 percent of the total chlorinated solvents. The zone of influence for each injection was 15 to 20 feet, maximum, and the injection zones overlapped the zones of influence.

NANOMATERIALS for ENVIRONMENTAL REMEDIATION

Glen Fryxell (DOE/PNNL) said that one of the advantages of nanotechnology is that the materials developed for remediation processes can be readily tailored to sensing and detection (See Attachment M). For example, the Self-Assembled Monolayers on Mesoporous Supports (SAMMS) technology starts with a glass honeycomb that condenses a huge amount of surface area into a very small space. The technology is based on rigid silica, which does not swell and shrink like polymer. The SAMMS ligand design can be tailored to remove specific contaminants, such as mercury or chromate. It is the only technology known to do that. Scientists at Pacific Northwest National Lab (PNNL), who were trying to make an injectable form of SAMMS, discovered that nanoparticulate titanium (TiNano40™) could be useful. While SAMMS works well for chemical separations, ligands are organic and are, therefore, problematic for sequestering radioactive elements. PNNL has been working on the development of nanoporous ceramic oxides coated with inorganic reactive oxides with an eye toward applying the technology to the immobilization of radioactive wastes at Yucca Mountain. Research at the laboratory is actively aimed at using nanotechnology to solve problems associated with environmental contamination.

Question: Has this work moved beyond the test-tube stage and into application?

Answer: Yes. SAMMS technology has been demonstrated on real-world waste streams, such as mercury in 50 to 100 gallons of vacuum pump oil at Oak Ridge National Laboratory. PNNL is in the process of commercializing SAMMS material and developing processes to produce it in batches of 100 to 1000 kilos. It has not yet been deployed in the field, but a project to clean produced water from an off-shore drilling platform is under consideration.

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Question: Have you looked at rates of natural degradation or the life of SAMMS material?

Answer: No, that depends on the half-life of the isotope involved. Organic ligands made in 1997 are still operational. We haven't examined them for attenuation rates.

Question: Are you planning to apply this technology to the Hanford plume?

Answer: Yes. Fryxell will be happy to respond to calls or emails with further details.

Question: What applications are planned for Yucca Mountain?

Answer: We hope to be packing and applying getter materials, but remember—the end game is 1500 years away!

NEXT MEETING AGENDA AND WRAP-UP

Walt Kovalick reminded participants that the next meeting will be held in December, and the meeting adjourned. He reminded participants that a summary of this meeting and all the PowerPoint presentations will be available in about a month for view or download from the FRTR web site at <http://www.frtr.gov/meetings.htm>.