FEDERAL REMEDIATION TECHNOLOGIES ROUNDTABLE MEETING
Arlington, Virginia
December 6, 2006

ATTACHMENTS*

A. **AFCEE Technology Transfer Program Update**
B. **New Report: 1,4-Dioxane Treatment Technologies**
C. **FRTR Future Direction**
D. **DoD Emerging Contaminants Initiative**
E. **Contaminants of Emerging Concern in Human and Animal Wastewaters: Recent Research Activities of the U.S. Geological Survey**
F. **Biodegradation of Ether-Containing Pollutants**
G. **Biodegradation of NDMA and Alternative Fuel Oxygenates**
H. **Case Study: NDMA Treatment at White Sands Test Facility**

*Links provided to presentations on the Meeting Proceedings page.

Federal Remediation Technologies Roundtable Meeting, Arlington, VA, December 6, 2006

I. Munitions: Area-Wide Assessments

J. Full-Scale Treatment of 1,4-Dioxane Using a Bioreactor

*Links provided to presentations on the Meeting Proceedings page.

FEDERAL REMEDIATION TECHNOLOGIES ROUNDTABLE MEETING

Arlington, Virginia
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ACTION ITEMS

- EPA will explore a way to facilitate use of the cost and performance case studies on the FRTR web site (possibly through an Internet seminar).
- EPA will work with other FRTR agencies to establish better connections among the various agency Web sites
- All FRTR member agencies are to notify Dan Powell (EPA) if they want to participate in the revived Subgroup on Site Characterization, which will be the forum for federal policy discussions related to Triad, and name a point-of-contact for that activity.
- All agencies are requested to provide Dan Powell with ideas for optimizing Triad training.

WELCOME/OPENING REMARKS

Walt Kovalick (U.S. EPA/OSRTI) welcomed the attendees to the 33rd meeting of the Federal Remediation Technologies Roundtable (FRTR) and provided a brief overview of the agenda. Kovalick noted that emerging contaminants would be the technical topic for the meeting. He also announced that he will be relocating to Chicago in January to serve as the Director and Assistant Regional Administrator for Resources Management for EPA Region 5. He will be exchanging positions with Norman Niedergang, currently in Region 5, who will assume Kovalick's duties as Director of the Technology Innovation and Field Services Division at EPA Headquarters. Niedergang was participating in the meeting by phone and was introduced to the group. Kovalick said that, in light of the change, a discussion on the future of FRTR has also been included on the agenda. Participants introduced themselves (a list of participants is attached to this copy for EPA's files only; it will not appear on the FRTR website).

AFCEE TECHNOLOGY TRANSFER PROGRAM UPDATE

David Carrillo (AFCEE) briefly outlined the structure and function of the Air Force Center for Environmental Excellence (AFCEE), saying that it is committed to technology demonstration and deployment instead of proprietary research and development (see Attachment A). He described the AFCEE technology transfer process, highlighting how needs and potential resources are identified through interaction with clients within the Air Force and how technologies move through the process. He said that the AFCEE program has saved the Air Force a total of $738 million, which represents an 11:1 return on investment (ROI). In terms of individual technologies, the Air Force has realized the largest savings ($525 million) and ROI (45:1) through the use of natural attenuation at 45 sites. Remedial process optimization, which has been implemented throughout the Air Force, has resulted in savings of $120 million (12:1 ROI), and bioremediation and bioventing, used at 176 sites, have yielded savings of $54 million (5:1 ROI). A total of 165 sites have been closed.

AFCEE has done considerable work with enhanced *in situ* bioremediation (EISB), or biowalls. A biowall protocol is in draft with publication scheduled for Feb 07. A short course presentation is also available. A training course will be offered in April 07 in San Antonio, as well as a short course with the EPA at the Battelle conference in May in Baltimore (MD). Biowalls have several

advantages, including minimal maintenance requirements, low construction costs, and use of simple organic material. Biowalls have been very successful at several sites and success at the pilot scale has led to full scale applications. Pilot- and full-scale biowalls targeting chlorinated solvents have been installed to date at Offutt Air Force Base (AFB) in Nebraska, Altus AFB (OK), Dover AFB (DE), Ellsworth AFB (SD), F.E. Warren AFB (WY), and Whiteman AFB (MO), Naval Air Station Fort Worth Joint Reserve Base (TX), and Seneca Army Depot (NY). A full-scale biowall has been installed at Naval Weapons Industrial Reserve Plant MacGregor (TX) to address perchlorate, chlorinated solvents, and royal demolition explosive (RDX). DoD's Environmental Security Technology Certification Program (ESTCP) funding has been used to install a pilot-scale biowall, which targets RDX, at Pueblo Army Depot (CO) and will support installation of the full-scale biowall targeting perchlorate, chlorinated solvents, and RDX at Redstone Army Arsenal (AL) early in 2007. To obtain reports and other documents related to these installations, visit the AFCEE Web site at http://www.afcee.brooks.af.mil/products/techtrans/bioremediation/BIOREMoverview.asp. Optimization of biowalls using biogeochemical reactions also is underway.

Review of fiscal year 2005 reveals $24.8M spent on long term monitoring (LTM) and $51.8M spent on remedial system operations and maintenance (O&M). Of the $51.8M, $25.6 was spent on pump-and-treat systems which have the longest operating lifetime of around 27 years. Carrillo also described AFCEE's work on a $5M weapon system pollution prevention (P2) program. P2 has been utilized in developing environmentally advantaged radar absorbing material, low temperature cure powder coating, and environmentally advantaged aircraft deicing fluids (ADF). In response to a question from Dan Powell (USEPA/OSRTI) about how AFCEE feeds its technology pipeline, Carrillo said AFCEE relies on ESTCP, the Small Business Innovation Research (SBIR) Program as well as consultation with industry.

FEDERAL AGENCY TRIAD EFFORTS

Dan Powell (USEPA/OSRTI) reported that FRTR member agencies have been working jointly to encourage implementation of the Triad process and to provide tools to help site managers use best management practices. He suggested that the Roundtable consider resurrecting its Site Characterization Subgroup to further efforts to raise awareness among practitioners within the federal government and to spread lessons learned from actual Triad projects. The subgroup also could serve as a vehicle to stimulate joint projects.

To date, EPA and other FRTR agencies have taken a number of steps to promote the Triad concept to federal program managers. EPA offers Triad training through a CERCLA Education Center course and several Internet seminars. The Army Corps of Engineers and the Air Force have developed Triad training for their personnel, and the Navy is working on similar training. Agencies have worked jointly through the Intergovernmental Data Quality Task Force (IDQTF) to develop the Uniform Federal Policy (UFP)-Quality Assurance Project Plans (QAPP) guidance, which streamlines the process of documenting the systematic project planning process and data collection plans. Still needed, however, are a better inventory and coordination among agencies of Triad training opportunities, including possibly sharing instructors. Additional case studies that document Triad best management practices in cleanup projects are needed as well as more tools to help practitioners implement these practices at their own sites.

He said that the Triad Community of Practice (CoP) has been functioning for almost two years. The CoP includes representatives of federal, state, private sector, and academic organizations that are using Triad in the field. The group, which now includes participants from the European Union (EU) countries, gets together via conference call monthly to exchange ideas, talk about barriers and other issues faced in real projects, and discuss how to educate others in the use of the process. The Triad concept already has been embraced by the Interstate Technology Regulatory Council (ITRC), and ITRC has published guidance for state regulators on Triad implementation. In addition, the new Field Analytical Suppliers Association (FASA) in the United Kingdom has expressed interest in promoting the use of Triad in cleanups performed by members of the EU and forming an EU CoP.

Powell said that the FRTR Site Characterization Subgroup would be the most appropriate forum for discussing federal policy issues related to Triad. He asked meeting participants if they would support reinstating the Site Characterization Subgroup. There was general agreement. Powell asked all participants to appoint points-of-contact from their agencies for the Subgroup and to provide him with any additional ideas they might have to optimizing Triad training.

NEW REPORT: 1, 4-DIOXANE TREATMENT TECHNOLOGIES

Marti Otto (USEPA/OSRTI) outlined Treatment Technologies for 1,4-Dioxane: Fundamentals and Field Application (see Attachment B). 1, 4-dioxane, also known as $C_4H_8O_2$, is a colorless, flammable, and hydrophilic liquid. It has a low Henry's Law constant and migrates rapidly in groundwater, as opposed to subsurface organic material, which tends to be more spatially stable. It is often found at sites with 1, 1, 1-trichloroethane (TCA) contamination. The report includes information on field applications of the following treatment technologies: *ex situ* advanced oxidation (for example, hydrogen peroxide with either ultraviolet or ozone exposure), *ex situ* adsorption using granular activated charcoal (GAC), and bioremediation. Note that GAC is being used at Stanford Linear Accelerator Center (SLAC) in CA. However, in theory, based on the properties of 1,4-dioxane, GAC should not be effective for 1,4-dioxane contamination. The success at SLAC may be due to very low influent concentrations, low flow rates, or perhaps biodegradation of dioxane on the carbon surfaces due to the presence of tetrahydrofuran.

Ongoing research on 1, 4-dioxane treatment is exploring how to successfully use biodegradation, phytoremediation, photocatalysis, and in-well treatment trains. The report can be found online at http://cluin.org/542R06009. For more information, search for the term 1,4-Dioxane at www.cluin.org, or contact Otto (contact information can be found on the attached participant list).

FRTR FUTURE DIRECTION

Walt Kovalick said that in its 16 years, the FRTR has established a strong legacy of building bridges between agencies, sharing and compiling information, and coordinating efforts (see Attachment C). Several ongoing FRTR projects provide opportunities for the FRTR to consider as it anticipates the future.

- The availability of the Internet makes it possible to expand FRTR's target audience through Web broadcasting, further improvement to the FRTR Web site (www.frtr.gov), expanding its links to participating agencies' Web sites. Should these be pursued?
- The FRTR has successfully produced nearly 700 cost and performance reports on assessment and cleanup technologies. Should this effort continue?
- The screening tools for site characterization and remediation technologies supported by FRTR and accessible through its Web site have been very popular. Should FRTR continue to support and update these tools?
- FRTR has also supported cross-cutting analyses, such as development of the matrix on decision support software. The matrix provides "Consumer Reports"-type evaluations of the public software for cost assessment that is available via the Internet. Should this effort continue?
- The Roundtable supported the effort by EPA, DoD, and DOE to assess the long-term performance of permeable reactive barriers (PRBs) in 2002. Similar reports have been prepared on a variety of technologies and are posted on the FRTR Web site. Should FRTR continue to support these efforts?
- What can FRTR do to continue to improve the practice of site remediation and showcase effective technologies?
- Would reviving FRTR Subgroups on specific issue areas increase the value of the outputs of future meetings?
- Should the FRTR expand its focus beyond technologies?

Kovalick indicated that, based on past input, there are three potential topics for the focused technical discussion at the next Roundtable meeting, which will be held in May 2007:

- Air emission control and monitoring technologies/collaborative opportunities for waste site cleanup,
- Case studies on dense non-aqueous phase liquid (DNAPL) cleanups, and
- Reuse/revitalization.

He asked participants to provide input to John Kingscott (USEPA/OSRTI) on their topic choice by the end of the day's meeting.

He asked for feedback from member agencies about what they see as important future FRTR projects. Mark Schoppet (NASA) said that using screening tools, improving the Web site, expanding the target audience, and creating FRTR subgroups were all good ideas. David Carrillo also supported the use of screening tools and investment in the Web site. Mario Dumenigo (Navy) echoed the group's support for screening tools. He added that the cost and performance reports benefit everyone and FRTR should continue support for these projects. Charles Reeter (NFESC) suggested that the NAVFAC screening tools should be made available on the FRTR Web site as well and offered to make arrangements. Herb Buxton (U.S. Geological Survey) said that the two main benefits from FRTR activities are shared input on research priorities and the transfer of technology between agencies. He strongly supported the revival of subgroups. Beth Moore (U.S. Department of Energy) said that the FRTR Web site is an extremely valuable information source. She said that the FRTR should move forward on projects that support process improvement and cost reduction. She said that working together in this way also would

segue into the federal initiative from the Office of Budget Management (OMB) to coordinate research efforts to avoid funding overlapping research.

EMERGING CONTAMINANTS

DOD EMERGING CONTAMINANTS

Paul Yaroschak (Office of the Secretary of Defense) said that the U.S. Department of Defense (DoD) is trying to shift the way it regards emerging contaminants (ECs): to switch from reacting to emerging contaminants to being proactive in assessing their risk and preparing to deal with them (see Attachment D). DoD has worked with the Environmental Council of the States (ECOS) and the EPA to frame a definition for an emerging contaminant, or EC, and identify policy issues related to ECs that need to be resolved. An EC must be a chemical or material that poses a perceived or real threat to human health or the environment with no peer reviewed health standard or an evolving standard. ECs usually have insufficient or limited health, science or technology information available. They may also become of interest because a new source, pathway or detection limit has been discovered. A recent USGS survey of 139 streams in 30 states found ECs in 80 percent of the streams, evidence of an emerging problem. ECs can affect the DoD and other agencies by adversely affecting operating forces and employees, reducing training and readiness, restricting access to certain materials, and increasing O&M and/or cleanup costs. Yaroschak emphasized that a small front end investment in early EC identification and risk management actions can result in huge savings from reduced health impacts, cleanup and compliance costs, readiness impacts, and platform and facility life cycle costs. He said that a coordinated approach would make it possible to predict which chemicals might become a threat, develop a consensus evaluation of the risks posed, identify risk management options, and achieve and measure risk reduction.

DoD has developed an EC Initiative and created an ECs Directorate to deal with a host of EC issues. A process has been developed tracking ECs. The first step is an over-the-horizon scan to identify ECs of interest. Second, the agency is compiling a Watch List of chemicals with possible impacts on DoD and will conduct Phase 1 impact analyses on these chemicals. Lastly, the chemicals found to have probable high DoD impacts will be placed on an Action List and more in-depth impact assessments and risk management options analyses will be done. DoD is using "risk cubes" to assist in identifying which chemicals are particularly harmful and can/should be preemptively addressed on a cost effective basis. Some chemicals that are currently on DoD's EC Watch List are: beryllium, dichlorobenzenes, and nanomaterials. The current EC Action List includes perchlorate, RDX, trichloroethene (TCE), and naphthalene.

Yaroschak outlined three EC research needs: identifying gaps in toxicology and risk assessments; finding less toxic but equally effective substitutions for selected ECs; and development of treatments for releases of ECs into the air, drinking water, wastewater, and soil.

The DoD and ECOS already have developed several products to address various EC-related issues. These include a state EC survey to understand how different states define ECs and which ECs pose the greatest concern; a paper focusing on how state and federal agencies can send a consistent risk message to the public; a paper offering provisional toxicity values for use when

no Integrated Risk Information System (IRIS) values are available, and an action triggers paper that describes the conditions, requirements, and authorities that influence the decision to expend public funds on EC response when the threat to human health is not clear.

In response to a question from Rob Steffan (Shaw Environmental, Inc) regarding naphthalene's inclusion on the EC Action List, Yaroschak said that EPA's draft risk assessment was somewhat controversial and that there is speculation that the regulated toxicity levels could be lowered considerably in the near future. This would create challenges for DoD because of naphthalene's natural occurrence in fuels.

CONTAMINANTS OF EMERGING CONCERN IN HUMAN AND ANIMAL WASTEWATERS: RECENT RESEARCH ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY

Herb Buxton (USGS) outlined four USGS research priorities related to ECs (see Attachment E). They include:

- Laboratory analytical methods to measure emerging contaminants in water, sediment and tissue;
- Environmental occurrence of ECs , their sources, and the source pathways by which they enter the environment;
- The biologic, chemical, and hydrologic processes that affect EC fate and transport; and
- Potential ecological effects of emerging contaminants in the environment.

Buxton said that, to date, USGS has the capability to measure 158 chemicals in water and 83 chemicals in sediment that it considers to be chemicals of emerging environmental concern. New analytical methods priorities for the USGS target several classes of pharmaceuticals (e.g., selective serotonin reuptake inhibitors and antibiotics), plus enhancing capabilities to detect ECs at lower levels. Study of the occurrence and source pathways of ECs has revealed that ECs are present as mixtures of up to 38 compounds in low concentrations in many water sources, and that this wide range reflects a number of human activities and inputs. Buxton identified septic tanks, municipal effluents, and hospital wastes as sources of ECs. He also identified virtually all forms of animal agriculture as sources of ECs. USGS's fate and transport research priorities related to ECs involve studying the transport process, environmental media, degradation byproducts, and the overall persistence of the various ECs. Buxton said that USGS has conducted studies at industrial plants, computer scrap yards, wastewater treatment plants, and other sites related to these four areas of concern. The USGS study of health effects from ECs has focused on endocrine disruption, antibiotic resistance and other effects on aquatic organisms.

BIODEGRADATION OF ETHER-CONTAINING POLLUTANTS

Rob Steffan (Shaw Environmental) said that ether-containing organic compounds are widely used as solvents, pesticides, gasoline additives, antibacterials, and a host of other applications (see Attachment F). Some, like 1,4-dioxane, tetrahydrofuran (THF), *bis* (2-chloroethyl) ether (BCEE), and methyl tertiary butyl ether (MTBE) have become important and challenging pollutants. Several have been detected at brownfields and Superfund sites. In general, they are chemically stable and exhibit biological recalcitrance. These contaminants resist treatment by

conventional treatment technologies such as air stripping and carbon absorption. Biological treatment has been applied for some of these contaminants with mixed results.

He reviewed the evolution of the scientific community's view of MTBE. In the 1980s the scientific literature said that MTBE would not biodegrade in sludge. The however, it became evident that MTBE biodegraded almost everywhere, he said. Researchers in the early 1990s reported finding no degradation in aquifers or soil. The first degradation of MTBE was reported in 1994 and by 2002 USGS reported that MTBE was degrading "everywhere we look." He cited two cultures that can be used to biodegrade MTBE, propane oxidizing bacteria (POB) and ENV735, and outlined the similarities and differences between them. The introduction of propane triggers the growth of the POB which leads to biostimulation and the utilization of adapted indigenous microbes. Advantages of biostimulation with propane include its low cost and relative abundance, its flexible implementation avenues (air sparging wells, permeable sparging wells, recirculating wells), and its ability to degrade both MBTE and TBA. Steffan reviewed a case study from a New Jersey site in which propane biostimulation was used and found that MTBE concentrations were reduced as much as 93% and only required $240 of propane and 18 liters of bacteria.

Steffan reported that in the early 2000s, public interest in MTBE waned as MTBE began disappearing at many sites. He said that this change could be attributed to the evolution or enrichment of the indigenous bacteria responsible for MTBE in contaminated aquifers or that gasoline components and their oxidation products support co-metabolic MTBE degradation.

Addressing the biodegradation of 1, 4-dioxane, Steffan cited a white paper on Solvent Stabilizers by Tom Mohr, Santa Clara (CA) Valley Water District, as an excellent source of information on 1,4-dioxane. The paper is available at http://www.valleywater.org. Steffan noted that 1,4-dioxane is chemically stable, very mobile in groundwater, and difficult to biodegrade or remove from the ground by air stripping or carbon sorption. He described the use of Strain ENV478 in degrading 1, 4-dioxane in microcosm studies. The study found that there was no degradation under anaerobic conditions, no degradation by native microbes, and that there was some degradation with bioaugmentation. He concluded that biological treatment of 1, 4-dioxane is possible, but not yet proven. He listed *ex situ* treatment in bioreactors, *in situ* treatment via co-metabolism, and *in situ* treatment via bioaugmentation as possible treatment methods. Steffan also described research on degradation of BCEE. *Pseudonocardia* sp. Strain ENV478 has been found to use a monooxygenase pathway to degrade BCEE. Enrichment culturing has led to development of *Xanthobacter* sp. ENV481, which also degrades BCEE.

Steffan said that, overall, there are many xenobiotic and natural ethers, a few common degradation mechanisms, and that anaerobic mechanisms are less understood. In response to a question, Steffan said that his company is focusing on bioremediation techniques to degrade ether-containing pollutants because it is often the least expensive method in environmental breakdown as compared to other chemical, physical, and biological methods and is his main area of focus.

BIODEGRADATION OF NDMA AND ALTERNATIVE FUEL OXYGENATES

Paul Bradley (USGS) analyzed five surface-water systems—Fort Pond, a beach on Great South Bay, a tidal creek on Great South Bay, Carmans River, and Tiana Bay—on Long Island, NY (see Attachment G). Overall, the microcosm study found that mineralization of MTBE, t-butyl alcohol (TBA), and tert-amyl methyl ether (TAME) was apparent in each system under oxic conditions and depressed under anoxic conditions. Relative biodegradability varied widely from system to system.

Bradley also reported on research into the effect of redox on TBA biodegradation in surface-water sediments, which found that there was efficient biodegradation under oxic condition, no degradation under methanogenic conditions, no degradation under heat-sterilized conditions, and that there is significant potential for biodegradation under manganese IV (Mn[IV]), nitrate (NO_3), and sulphate (SO_4) reducing conditions. In addition, he described results of a study of biodegradation of N-Nitrosodimethylamine (NDMA) in soil at a water reclamation facility. NDMA is a toxin, an animal carcinogen and suspected human carcinogen, and a byproduct of rocket fuel, nitroaromatics explosives, and water treatment processes. A microcosm experiment, using soil from a typical suburban backyard, revealed significant potential for NDMA biodegradation under oxic conditions, and significant but less efficient degradation under anoxic conditions. Bradley explained that continued study of NDMA is important because of its potential threat to drinking-water supplies. Currently, California has a drinking-water standard of 10 ng/L for NDMA. NDMA has been found at levels up to 100 ng/L in treated water, however.

CASE STUDY: NDMA TREATMENT AT WHITE SANDS TEST FACILITY

Mike Zigmond (NASA) presented a case study on the treatment of the carcinogen NDMA in groundwater at the NASA White Sands Test Facility (WSTF) in New Mexico (see Attachment H). In addition to NDMA, the contamination at WSTF also includes N-Nitrodimethylamine (DMN), trichloroethene (TCE), and tetrachloroethene (PCE), which are all a result of historical rocket engine testing operations carried out at the facility. In 1987, NDMA was detected in two WSTF monitoring wells at levels of about 15,000 parts per trillion (ppt). WSTF worked with the Southwest Research Institute (SwRI) to improve detection and characterization of the NDMA plume at the facility. SwRI modified Method 607 for analysis of NDMA by using mass spectrometry as a detector. SwRI subsequently developed a low-level NDMA method using high-resolution gas chromatography and high-resolution mass spectrometry as detectors. The low-level NDMA method has been approved for use in California by the California Department of Health Services and the New Mexico Environment Department (NMED) also has approved NASA's use of the modified method. The method detection limits (MDLs) of Method 607, modified Method 607, and the low-level NDMA method are 150 ppt, 5 ppt, and 0.2 ppt, respectively.

Zigmond explained that the cancer risk of NDMA is the driving force behind remediation of WSTF's groundwater. EPA classified NDMA as a probable human carcinogen and that the assumed exposure to 1.3 ppt NDMA translates to a cancer risk of 1×10^{-6}. NMED uses the same assumptions but also has a cumulative cancer risk standard (NDMA, DMN, TCE, and PCE together) of 1×10^{-5}. Using the lower MDL with the modified Method 607, the cancer risk of NDMA is calculated to be 3.0×10^{-6} for a 30-year-old adult and 3.8×10^{-6} for a 6-year-old child.

A pump-and-treat system is being used to remediate WSTF groundwater. The plume-front treatment system has included use of an ultraviolet (UV) oxidation reactor. To date, NASA has invested about $9 million in design and construction. After rehabilitating and testing injection wells in 2004-2005, operation began in September 2005 and continued through August 2006. As of July 2006, the cumulative cancer risk was estimated at 3.3×10^{-3} for influent to the system and 8.3×10^{-6} for effluent. Future plans call for design and installation of a treatment system in the middle part of the plume, continued investigation of source areas, and continued monitoring of developments remediation and analytical technology for NDMA. In response to a question from Gerald DiCerbo (DOE), Zigmond noted that NASA had conducted a significant amount of modeling on how long the cleanup would take and has found that it should take around 60 years In response to another question, he said that the bulk of the operational cost has been the $300,000/year electric bill from the UV reactor. Zigmond said that WSTF is a RCRA cleanup; the original drivers were an Administrative Order on Consent from EPA Region 6 and the New Mexico State Groundwater Standard for cumulative cancer risk. Walt Kovalick commented on the remoteness of WSTF, and Zigmond confirmed that the nearest town is six miles away and that the facility's drinking-water wells are the only installations threatened by the plume.

MUNITIONS: WIDE-AREA ASSESSMENTS

Doug Maddox (U.S. EPA/FFRRO) reported on the unexploded ordnance (UXO) wide-area assessment (WAA) technologies being used to find bombs from firing and test ranges (see Attachment I). The DoD munitions response program is for closed sites only and contains more than 3,300 munitions response sites. The land involved covers more than 15 million acres and could cost $8-35 billion to clean up over a course of more than 75 years. Currently there are two highly successful munitions detection technologies: electromagnetic induction (EMI) and magnetometry based platforms. Other technologies such as ground penetrating radar and explosive sniffers are too limited to be broadly applied. There are three types of detection platforms: hand-held, man-portable, and vehicle-towed, airborne, or underwater tools. WAA uses a layered technology approach combining well characterized technologies—high altitude airborne to detect ordnance features, low altitude airborne magnetics, and ground-based magnetic and EMI transect sampling—with other selected processes depending on specific objectives. DoD requires extensive validation before labeling a given area as being free of UXO. Two sites where these technologies are being demonstrated are Camp Beale (CA) and Toussaint River (OH) (where much of the UXO is underwater and occasionally washes up on shore).

Maddox noted that finding a target is relatively easy, but that proving that no munitions are present is more difficult and requires defining the data needs and optimal platforms for a particular site. In response to a question about missile penetration depth of munitions, Maddox reported that the average depth variable. Some smaller (20-37 mm) munitions, however, have a propensity to go deeper than can be detected. In response to another question, Maddox verified that DoD routinely uses available historical site photos in developing its approach to detecting and remediating UXOs.

FULL-SCALE TREATMENT OF 1, 4-DIOXANE USING A BIOREACTOR

Tim Shangraw (Engineering Management Support, Inc.) and William Plaehn (Parsons Corporation) reported on a full-scale treatment of 1, 4-dioxane using a bioreactor (see

Attachment J). The Lowry Landfill Superfund Site, just outside of Denver (CO) is a 480-acre industrial and municipal landfill that operated from the mid-1960s to 1980 and disposed an estimate 138 million gallons of liquid industrial wastes to unlined pits during that period. It became a Superfund site in 1984, and a Record of Decision for containment of groundwater was issued in 1994. At this site, there were two primary waste streams, the North Boundary Barrier Wall (NBBW) and the North Toe Extraction System (NTES). The former had a flow rate of 7-10 gpm and a low concentration of organic material, and the latter had a flow rate of .5-3 gpm and a high concentration of organic material. A treatment train of several processes and technologies at the on-site water treatment plant was found to be unable to remove 1,4-dioxane to below the permitted level of 2 parts per million (ppm) due to poor UV transmittance, hydroxyl scavenging with NTES waters, and poor sorption on GAC. EMSI and Parsons evaluated chemical precipitation, advanced oxidation processes, thermal treatment, and biological treatment as possible alternatives. After bench- and pilot-scale studies, they concluded that biodegradation of 1,4-dioxane would be feasible using a feed that blended the two waste streams, 23° C would be the optimal temperature for balancing reaction efficiency and energy costs, and the degradation of 1,4-dioxane and THF could be promoted using the indigenous bacteria efficiently and consistently at tested organic loadings. These results supported moving forward to full-scale biological treatment.

The full-scale system included a 300-gallon sedimentation tank for coarse solids sedimentation; a 300-gallon blend tank for blending, pH adjustments, and phosphorous addition; three aerobic, fixed-film, moving-bed bioreactors (MBBRs); coarse bubble diffusers for aeration and mixing; and an effluent tank with a recycle line to feed effluent back through the system for further treatment. Full-scale operations began in January 2005 with a maximum flow rate of 6 gpm. Researchers found that the system could successfully reduce 1, 4-dioxane contamination of up to 25,000 ppb in wastewater to less than 1,000 ppb and reduce THF contamination of 60,000 ppb to less than 1,000 ppb through degradation with indigenous bacteria. High removal efficiency can be achieved with a temperature of around 23 degrees and organic loading between 0.04 and 0.07 grams D&T COD/ grams TS*d. Nitrification could occur with no inhibitory effect on 1, 4-dioxane degradation. The robustness of the biological system eliminated the need for UV oxidation, greatly reducing the cost of operation.

MEETING WRAP-UP

Walt Kovalick reiterated that the next FRTR meeting will be held in May 2007 at One Potomac Yard and said that, based on the input received, DNAPL case studies would be the technical topic for the meeting. He said that the Air emission control and monitoring technologies/ collaborative opportunities for waste site cleanup and reuse/revitalization/ecological restoration topics would be kept on the list for future consideration. Kovalick said that the action items from this meeting include exploring a way to facilitate use of the cost and performance case studies on the FRTR web site (possibly through an Internet seminar), working on establishing better connections among the web sites of the various FRTR member agencies, notifying Dan Powell about a point-of-contact from each agency to participate in the revived Subgroup on Site Characterization, and to providing to Dan any additional ideas participants might have to optimizing Triad training.

The meeting was adjourned.