FEDERAL REMEDIATION TECHNOLOGIES ROUNDTABLE MEETING
Arlington, VA
November 14, 2012

ACTION ITEMS

- Each agency interested in participating in an FRTR subgroup that would work on aspects of end states will send the name of an agency representative or volunteer to Jessica Burns (jessica.burns@emsus.com) by Friday, November 16.
- Jessica Burns will forward notes on actionable items for the subgroup to the individuals expressing interest in participating.
- Monthly subgroup calls will be set up late November or early December.
- Links of interest will be posted directly to the FRTR website in addition to the presentations (?)

WELCOME/INTRODUCTION/ADMINISTRATIVE BUSINESS

Greg Gervais, Chief of the EPA Technology Innovation and Field Services Division (TIFSD), Technology Assessment Branch, welcomed the attendees to the 45th meeting of the Federal Remediation Technologies Roundtable (FRTR). The theme of this meeting was Cleanup of Contaminated Sites: Overview of End States, Current Challenges and Future Opportunities. FRTR works to build a collaborative atmosphere among federal agencies involved in hazardous waste site cleanup. The FRTR website (www.frtr.gov) highlights case studies from member agencies, cost and performance reports, and other information.

FRTR ANNOUNCEMENTS AND MEETING OBJECTIVES

FRTR Agency Announcements (Projects/Initiatives)

Greg Gervais provided an update on recent EPA initiatives.

- Twelve new sites have been added and eight sites have been proposed for addition to the National Priorities List (NPL) since the June 2012 FRTR meeting. Sites added and proposed for listing on the NPL include ammunition manufacturing facilities, scrap metal facilities, electroplating facilities, wood treaters, chemical manufacturers, and groundwater plumes. More information on these sites can be found at http://epa.gov/superfund/.
- EPA finalized and released the *National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion* in September 2012. The goals of the Strategy are to expand and formalize optimization practices as an operating business model for the Superfund remedial program. More information can be found at http://www.epa.gov/superfund/cleanup/postconstruction/optimize.htm.
- The Citizen's Guide series has recently been updated and posted on http://www.epa.gov/superfund/community/publications.htm#guides. The Citizen's Guide series is a set of 22 fact sheets that summarize cleanup methods used at Superfund and other sites. Citizen's Guides are illustrated and contain case studies to assist site managers in their community involvement efforts. Spanish translations of the updated Citizen's Guides, along with PowerPoint slides and other multimedia, will be published in several months.
- New Green Remediation Best Management Practices fact sheets on mining sites and in situ thermal treatment have been added to the Green Remediation focus area on CLU-IN (http://www.clu-in.org/greenremediation/).

- New division directors have joined the Office of Superfund Remediation and Technology Innovation. Pamela Barr is the new Director of the Technology Innovation and Field Services Division, while Rebecca Clark became the new Director of the Assessment and Remediation Division.

Skip Chamberlain, Department of Energy (DOE), reported that the DOE has been pushing forward an initiative on end states. In addition, several soil vapor extraction cost and performance reports have been completed. Over the next year, DOE's Office of Environmental Management anticipates using the recently published National Research Council of the National Academies study (*Alternatives for Managing the Nation's Complex Contaminated Groundwater Sites*, available at http://dels.nas.edu/Report/Alternatives-Managing-Nation/14668), sponsored by the U.S. Department of the Army, to form the basis and framework for its own National Academies study in the coming year. The study would explore stakeholder-regulatory relations and different types of end states in-depth. More details on the study will likely be available during the Spring 2013 FRTR meeting. In addition, DOE is continuing work at the Hanford site and the Y12 National Security Complex. Finally, DOE is looking to complete several additional cost and performance reports in the near future.

David Carillo, U.S. Air Force, reported that major reorganization is occurring in Texas and Florida, which includes the merge of Air Force Center for Engineering and the Environment and the Air Force Real Property Agency in Texas with the Air Force Civil Engineer Support Agency at Tyndall Air Force Base in Florida, into one field operating agency: the Air Force Civil Engineer Center (AFCEC). Telephone numbers of Air Force personnel affected by the merge have not changed.

Emily Joseph, Department of the Interior (DOI) Office of Environmental Policy and Compliance reported that DOI has implemented a new administrative record screening initiative. In addition, DOI is planning to conduct its annual internal control reviews at approximately 10 project sites to ensure project funds are being used appropriately. DOI will conduct about five reviews in the field and will complete the rest remotely from headquarters. Finally, a webinar series on topics such as medical monitoring at sites and creation of administrative records will be launched in the near future.

Tom Nicholson, U.S. Nuclear Regulatory Commission (NRC), reported that on December 17, the NRC will be implementing the new rule 10 CFR 20.1406(c), which requires all nuclear licensees to evaluate subsurface residual radioactivity and whether there are sufficient surety bond resources for remediation at the time of decommissioning.

Robert Kirgan, U.S. Army Environmental Command (USAEC), reported that he and several colleagues have reviewed the FRTR website and identified about 30 pages of material that needs to be corrected and updated. His team will begin the update process with the FRTR Remediation Technologies Screening Matrix.

Kim Brown, Naval Facilities Engineering Command (NAVFAC) Headquarters, Environmental Restoration Division, reported that the Department of the Navy is promoting optimization to field office in an effort to deal with more challenging sites. The Department of the Navy updated its Policy for Optimizing Remedial and Removal Actions at all Department of the Navy Environmental Restoration Program Sites in April 2012 (https://portal.navfac.navy.mil/portal/page/portal/navfac/navfac_ww_pp/navfac_nfesc_pp/environmental/erb/resourceerb/don_policy_opt_2012-04-02.pdf). In addition, the Department of the Navy anticipates conducting optimization reviews jointly with EPA in December 2012. Kim also reported that the Naval Facilities Expeditionary Logistics Center (NAVFAC ELC) and the Naval Facilities Engineering Service Center (NAVFAC ESC) have consolidated to form the Naval Facilities Engineering and Expeditionary Warfare Center (NAVFAC EXWC). Additionally, NAVFAC Headquarters has undergone several personnel changes: Brian Harrison is retiring after about 26 years of service and Robert Sadorra will take his place as Director of the Environmental Restoration Division. Gunarti Coghlan, who recently joined NAVFAC Headquarters, will be joining FRTR meetings in the future.

Deborah Morefield, Program Manager for the Defense Environmental Restoration Program in the Office of the Deputy under the Secretary of Defense (Installations and Environment), reported that her office has been working with EPA on numerous initiatives in the cleanup program. One of the major initiatives is looking at inventory management. She commended EPA on its efforts to conduct quality assurance and quality control of the CERCLIS database and reported that the Department of Defense (DOD) has been examining its databases to determine whether CERCLIS updates can be tracked and DOD data stays in sync with CERCLIS data. The examination revealed that DOD and EPA data on NPL sites were within 5% of each other. DOD is now beginning to look at non-NPL data and its state partners. She emphasized the importance of continuing this effort, as well as cleaning up the docket list.

Carol Dona, U.S. Army Corps of Engineers (USACE), reported that USACE has finished four Army studies. Carol conducted a green and sustainable remediation (GSR) study; Laurie Haines, USAEC, played an active role in the study. Carol will meet with the U.S. Army on November 15 to discuss the potential of implementing an Army-wide policy and guidance on GSR. Other study topics included optimization. USACE anticipates following up on the optimization study to examine following of recommendations in terms of implementation.

Vapor Intrusion Subgroup

Greg Gervais said that he spoke with the FRTR vapor intrusion subgroup, but it had no recent activity to share since the last FRTR meeting.

Green and Sustainable Remediation Subgroup

Greg Gervais reported that the FRTR GSR subgroup is incorporating optimization into its work as it moves forward. A full FRTR meeting on optimization was held several years ago, where it was recognized that GSR and optimization share numerous principles. Carol Dona reported that a trial GSR hands-on training workshop was held on November 13. The training will be modified to address participant comments and used during a future FRTR meeting on GSR to partially replace the lecture.

FRTR Interim Steering Committee

Greg Gervais reported that three steering committee meetings, including one face-to-face meeting, have been held since the last full FRTR meeting. The steering committee is continuing work on operationalizing the FRTR operating principles. One of the principles is annual rotation of the steering committee chair. Greg served as chair in calendar year 2012. Bill Lodder, DOI, will chair the steering committee for calendar year 2013. Emily Joseph will serve as backup for Bill on DOI activities. In addition, AFCEC has indicated a desire to participate in the steering committee since the last FRTR meeting. The steering committee will be working out the details on including AFCEC in the group. One of the main principles of FRTR is increased participation from all agencies and shared leadership in the steering committee.

KICKOFF OF THE TECHNICAL DISCUSSION ON END STATES

Paul Beam (DOE), meeting organizer, welcomed participants. He reiterated that the theme of the meeting is technical issues related to challenges and opportunities and end states at complex sites. Paul added that the remediation community is working to improve its understanding and communication with regard to end states at complex sites and emphasized the opportunity for collaboration on technical issues offered by the FRTR meeting. A panel session will be held in the latter part of the meeting to evaluate participants' interest in developing a group project on the topic.

OVERVIEW OF CHALLENGES AND OPPORTUNITIES

Overview of End States: Groundwater Remediation, Management and the Use of Alternative Endpoints at Highly Complex Sites

Rula Deeb, ARCADIS, discussed technical challenges, as well as remediation and risk management at highly complex sites, and provided an overview of alternative endpoints and other approaches. Rula clarified that 'end states' is a term used to reference the state of a site after cleanup is complete. End states can include institutional controls, long-term monitoring and management, or other active controls to clean up to standards. At highly complex sites, an unrestricted use determination is not likely to be attained and alternative endpoints may be used to make cleanup determinations, using the approaches mentioned above.

Highly complex sites possess the following characteristics: highly heterogeneous geology, contaminants located in fractured rock and sequestered in low permeability units, widespread regional contamination, and long-lived inorganic contaminants. Potential project risks at these sites include lack of an exit strategy, high cost of implementing a technology, and a long cleanup timeframe. Alternative endpoints are considered at highly complex sites and include Applicable or Relevant and Appropriate Requirements (ARAR) Waivers (technical impracticability [TI] waivers, greater risk waivers, and others), alternate concentration limits (ACLs), groundwater management and containment zones, and groundwater reclassification strategies. Other, informal approaches include monitored natural attenuation over long timeframes, adaptive site management, and low-threat closure.

TI Waivers are applicable to sites where it is "technically impracticable to meet cleanup requirements within a reasonable timeframe." EPA issued guidance regarding TI Waivers in 1993 (http://www.epa.gov/superfund/health/conmedia/gwdocs/techimp.htm). TI Waivers have been used at about 77 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites. The majority of TI Waivers have been based on contaminants (largely contaminant mixtures, chlorinated solvents, volatile organic compounds [VOCs], and metals) and site geologic setting (largely fractured rock, karst, and mining voids). A TI Waiver was used at a Resource Conservation and Recovery Act (RCRA) site in Connecticut, for example, which contained 133 areas of concern over 40 acres. The site was a former factory for aircraft engines and 1,1,1-trichloroethane in dense non-aqueous phase liquid (DNAPL) form was found in a multi-layer overburden aquifer. Feasibility studies showed that clean site closure was not feasible and remedial efforts would have potentially been ineffective and costly. Remediation was performed to the extent practicable, using excavation, in situ heating, in situ chemical oxidation (ISCO) using persulfate, and high-vacuum extraction for mobile non-aqueous phase liquid. A technical impracticability assessment was completed and received approval. As part of the long-term stewardship strategy at the site, modeling was performed to define the boundary at which to restrict groundwater use.

A greater risk waiver is another alternative endpoint and waives ARAR at sites where greater harm would result by conducting activities to meet ARAR. For example, a greater risk waiver may be used where activities to meet ARAR would result in DNAPL mobilization, damage to sensitive ecosystems or species, and technology-related health and safety risks. This type of waiver, however, is not used frequently. A greater risk waiver was used at the Onondaga Lake LCP Bridge Street Site in New York, which was contaminated with mercury DNAPL. Excavation and offsite transport of contaminated materials would have created a greater risk of exposure than managing the contamination in place. The site remedy included a greater risk waiver, slurry wall, pump-and-treat system, excavation of shallow soils, placement of a temporary cap, and long-term monitoring.

An ACL replaces or modifies groundwater cleanup requirements and can be calculated from surface water quality criteria. However, an ACL only applies to sites where contaminated groundwater discharges to surface water. An ACL was used at the Former Naval Station in Long Beach, California, where groundwater was contaminated with VOCs. The California Ocean Plan was used to establish ACLs after air sparging and vapor extraction treatment were complete. The site is currently in long-term management mode and land use controls are in place. Obtaining an ACL is a formal process. The EPA guidance for obtaining an ACL at CERCLA and RCRA site can be found here: http://www.epa.gov/superfund/health/conmedia/gwdocs/acls.htm.

Groundwater management, another type of alternative endpoint, is used to define areas that exceed water quality standards and manage contaminants in place. The meaning of groundwater management and terminology used varies by state. Formal designations are set within federal and state cleanup programs.

Informal approaches include monitored natural attenuation (MNA) over long timeframes. MNA is applied at sites where circumstances warrant and stakeholders accept a longer timeframe (i.e., about 100 years). A site in Orlando, Florida is an example of the use of MNA. Some of the site’s former uses included storage of waste oil/fuel drums and wash racks. Trichloroethene (TCE) was determined likely to be present as DNAPL. Past remedial activities ISCO using Fenton’s reagent as interim remedy to reduce total chlorinated VOCs below 500 µg/L, and enhanced bioremediation. MNA was then evaluated as an option. Several lines of evidence were studied carefully, such as whether geochemical conditions were favorable to support MNA and whether the plume was steady. The approach was supported by the partnering team despite a projected remedial timeframe of 60-70 years with source removal and VOC concentrations 10-100 times the Maximum Contaminant Levels (MCLs).

In summary, several options for alternative endpoints and other approaches exist for groundwater at complex sites. Factors that increase the likelihood of attaining approval for an alternative endpoint include broad stakeholder agreement, controlled risks and threats, contingency measures to protect human health and the environment, durable and reliable ways to manage long-term residutal contamination, receptiveness of regulatory agency and stakeholders, collaboration between stakeholders; and strategies to reduce communication barriers.

The key resources are the Interstate Technology and Regulatory Council (ITRC) Guidance Documents on remediation risk management, available at http://www.itrcweb.org/guidancedocument.asp?TID=71 and the ESTCP (2011) report on Assessing Alternative Endpoints for Groundwater Remediation at Contaminated Sites, available at www.serdp.org/content/download/10 619/130969/file/ER-200832-FR.pdf, and EPA policy guidance documents (http://www.epa.gov/superfund/health/conmedia/gwdocs/index.htm).

Question: What is a 'reasonable timeframe' and what is it based on? Does site remediation have to be conducted prior to obtaining a TI Waiver?
Answer: The EPA guidance (*Guidance for Evaluating Technical Impracticability of Ground-Water Restoration***,** OSWER Directive 9234.2-25, September, 1993, available at http://www.epa.gov/superfund/health/conmedia/gwdocs/techimp.htm) mentions that a reasonable timeframe is not quantified. A TI Waiver can be obtained before conducting active remediation.

Question: Tell us more about the way you evaluate risk. For example, do you look at ecosystems, human interactions, conceptual model uncertainties, and other factors?
Answer: Protection of human health and the environment is paramount. The risks discussed during the presentation refer to the risks of the remedy failing because the site is too complex.

EPA Groundwater Expectations: An Overview of CERCLA, the NCP, and EPA Policy and Guidance for Superfund Groundwater Response Actions

Kate Garufi, EPA, provided an overview of key existing Superfund groundwater policies to assist EPA in making groundwater restoration decisions pursuant to CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). She stated that EPA's mission is protecting human health and the environment. Remedies must be protective but also be consistent with CERCLA, as implemented by the NCP. In the groundwater arena, remedies must also restore groundwater to beneficial use. For more information, see the *Groundwater Road Map: Recommended Process for Restoring Contaminated Groundwater at Superfund Sites*, OSWER 9283.1-34, July 2011 (available at http://www.epa.gov/superfund/health/conmedia/gwdocs/index.htm).

According to the NCP, Superfund groundwater remedies are expected to "return usable groundwaters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site." In addition, "When restoration of groundwater to beneficial uses is not practicable, EPA expects to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction"

(40CFR300.430(a)(1)(iii)(F)). The definition of 'beneficial use' is based on the Superfund Groundwater Classification and Beneficial Use Policy or EPA-endorsed Comprehensive State Ground Water Protection Programs. EPA will defer to state designations that are not based on an EPA-endorsed Comprehensive State Ground Water Protection Programs, unless the action would lead to a less-stringent solution. More information can be found in the *Summary of Key Existing EPA CERCLA Policies for Groundwater Restoration*, OSWER Directive 9283.1-33, June 2009 (available at http://www.epa.gov/superfund/health/conmedia/gwdocs/index.htm), *The Role of CSGWPPs in EPA Remediation Programs*, OSWER Directive 9283.1-09, April 1997(available at…), and the *Guidelines for Ground-Water Classification Under the [1984] EPA Ground-Water Protection Strategy, Final Draft, EPA/440/6-86-007, November 1986* (available at http://www.epa.gov/osw/hazard/correctiveaction/resources/guidance/gw/gwclass.htm).

The five key CERCLA principles of groundwater remediation are: restoring current or potential sources of drinking water; preventing migration of contaminant plume; considering TI Waivers when restoration is impracticable, if statutory criteria are met; considering early actions, such as source removal, plume containment, and an alternate water supply; and not relying solely on institutional controls. A CERCLA remedial action may be warranted when a regulatory standard that helps define protectiveness is exceeded, the calculated estimated risk exceeds a carcinogenic level for an adverse health effect or the upper end of the NCP risk range for "cumulative carcinogenic site risk," the non-carcinogenic hazard index is greater than one, site contaminants cause adverse environmental impacts, or action may be warranted within the risk range given other factors (e.g., sensitive populations). For more information, see the *Summary of Key Existing EPA CERCLA Policies for Groundwater Restoration*, OSWER Directive 9283.1-33, June 2009 and the *Role of Baseline Risk Assessment in Superfund Remedy Selection Decisions*, OSWER Directive 9355.0-30, April 1991 (available at http://www.epa.gov/superfund/health/conmedia/gwdocs/index.htm) ARARs are used first to set remedial action cleanup levels for restoration remedial actions. If ARARs are not available or sufficiently protective, and carcinogens are found at the site, the cleanup level is set such that it represents an excess upper bound lifetime cancer risk between 10^{-4} and 10^{-6}, with 10^{-6} as the point of departure. If ARARs are not available or sufficiently protective and no carcinogens are present, the cleanup level is set such that the cumulative risk from exposure will not result in adverse effects to human populations. In the latter two cases, cleanup levels may be lowered based on factors such as multiple contaminants, sensitive sub-populations, and other factors. More information can be found in the *Summary of Key Existing EPA CERCLA Policies for Groundwater Restoration*, OSWER Directive 9283.1-33, June 2009.

If the Agency decides an ACL might be appropriate based on site-specific circumstances, CERCLA section 121 sets forth a number of specific requirements that must be met. CERCLA ACL provision is directed at standards that are "otherwise applicable for hazardous constituents in groundwater" (CERCLA section 121(d)(2)(B)(ii)). Examples of such standards may include state requirements to clean up groundwater to background levels. CERCLA section 121(d)(2)(B)(ii) also states that with an ACL, MCLs and water quality criteria would generally not be "applicable" but rather potentially "relevant and appropriate." Specific requirements under CERCLA for establishing an ACL include a known and projected point of entry, no significant increase in constituents, and enforceable measures to preclude human exposure before the point of entry. More information can be found in the *Use of Alternate Concentration Limits (CLs) in Superfund Cleanups,* OSWER 9200.4-39, July 19, 2005.

ARAR Waivers, such as TI Waivers, may be considered for groundwater restoration and granted under appropriate circumstances. A TI determination needs to be contaminant and media-specific. All waiver decisions need to be scientifically supported and clearly documented. More information can be found in the *Guidance for Evaluating Technical Impracticability of Ground-Water Restoration***,** OSWER Directive 9234.2-25, September 1993 and the *Use of Technical Impracticability Waivers at Superfund Sites*, OSWER Directive 9230.2-24, August 2012 (available at http://www.epa.gov/superfund/health/conmedia/gwdocs/techimp.htm).

In the case of restoration remedies, the area of attainment or point of compliance for achieving groundwater cleanup levels is generally expected to be throughout the plume or, where there is a waste management area, at the edge of the waste management area, in order for cleanup to be considered complete. For non-restoration remedies, cleanup can be considered complete when an alternative remedial strategy has been implemented and documented in a Record of Decision (ROD), institutional controls have been implemented, engineering containment and monitoring has been put in place, and all groundwater cleanup levels have been met at the point of compliance.

Question: Has EPA considered how tribal groundwater standards would or would not be considered as ARARs?
Answer: Robin Anderson (EPA) is the person best person able to answer that question. Tribal groundwater standards would be viewed as a state ARAR. When multiple ARARs are available, the more stringent ARAR is chosen.

Question: What is considered a ‘reasonable timeframe’?
Answer: The EPA 1993 *Guidance for Evaluating Technical Impracticability of Ground-Water Restoration* attempts to place an upper boundary on what is considered a reasonable timeframe. The guidance suggests that a long timeframe is 100 years. However, a TI Waiver is based on hydrogeology and contaminants. Some remedies are going to take longer, while others will take less time. Therefore, a ‘reasonable timeframe’ is very site-specific.

Question: How often do you require monitoring data to be collected to ensure that cleanup goals are being achieved?
Answer: EPA is required by statute to review the remedy every five years after it has been built. The 5-year review process requires EPA to examine whether the selected remedy is being protective. As long the remedy is protective, EPA does not promote obtaining a TI Waiver.

Defense Environmental Restoration Program Overview of Challenges and Opportunities

Deborah Morefield, Environmental Management Directorate, Office of the Deputy Under Secretary of Defense (Installations and Environment), stated that the Defense Environmental Restoration Program (DERP) addresses the impacts of releases of hazardous substances, military munitions, and building demolition and debris removal. The program functions under several authorities: CERCLA, the Superfund Amendments and Reauthorization Act, RCRA, and

Executive Order 12580. There are 34,869 DERP sites at 1,733 active installations, 234 Defense Base Closure and Realignment installations, and 2,696 formerly used defense sites.

The goals of DERP are to select and implement remedies at all sites to be protective of human health and the environment, use a prioritization system to address highest risk sites first, and to make well informed, intelligent, responsible remedy decisions. The overarching goal is to achieve Remedy in Place/Response Complete at Army, Navy, Air Force, and Defense Logistics Agency sites by fiscal year (FY) 2014. DERP has steadily progressed forward toward this goal since the 1990s due to dedicated funding for the program.

Despite the progress made by the DERP, numerous problematic groundwater sites with technical and regulatory challenges remain. Some of the technical issues encountered at these sites include large plumes with low contaminant concentrations, karst/fractured rock geology, high concentration source areas where even very aggressive treatment has little effect on mass flux, site risk, or timeframe for remediation, and source term desorbing from low permeability layers at low concentrations for long period. Regulatory issues include the perception that monitored natural attenuation is a lack of action, inconsistent implementation of TI Waivers across regions and states, and application of ARARs at the remedial investigation phase without site-specific risk assessment.

There are several strategies available to help with making better decisions at these types of sites. Two options are continuing to evaluate sites at 5-year reviews, and assessing trade-offs and applying savings at lower risk sites that could achieve site closure. In addition, the National Academies study points to alternative endpoints, exit strategies, and revised decision frameworks. There is an opportunity for collaboration for implementing the results of the study, which would require determining how operations that have reduced contamination but are no longer adding value can be assessed, working to achieve the same results at a lower cost, and developing decision criteria to select sites and change remedies while staying protective of human health and the environment.

Comment: Bill Levitan, DOE, stated that DOE has several large sites with contaminants that will likely remain in place for millennia. The cleanup timeframe under CERCLA is usually within the span of multiple decades. Under the Atomic Energy Act, the cleanup timeframe is several millennia. It is important for the remediation community to consider seriously whether a standards-based approach or a performance-based approach would be used at a specific site. In the radiation realm, a performance-based approach is typically used.

Question: Is DOD using net-benefit analysis to make decisions?
Answer: Rich Mach, Office of the DAS of the Navy, Environment, replied that the DOD tries to make the most educated decisions possible within the required regulatory framework. He added that every site is different and the ultimate decisions made are site-specific.

A Perspective on DOE Challenges and Opportunities for Alternative End States

Hope Lee, Pacific Northwest National Laboratory (PNNL), defined end states as the final remedial goals that are permitted by regulations and are protective of human health and the environment. She stated that alternative end states are needed for many remaining contaminated sites because they are typically very complex. The contaminants are frequently metals and radionuclides, while the actual contamination is located in deep, fractured rock. When determining an acceptable end state, tradeoffs must be carefully considered among the competing influences of cost, scientific defensibility, and the amount of acceptable uncertainty in meeting remediation decision objectives. The alternative end state that is most acceptable is one that is scientifically and technically defensible, has the highest regulatory acceptability, lowest uncertainty/risk, and lowest cost. Examples of such end states include in situ bioremediation and surface barriers.

Currently acceptable end states include enhanced and monitored natural attenuation, adaptive site management, groundwater reclassification, ACLs, and ARAR Waivers. An end state for a site is determined through a series of steps. Gathering of site data and source terms are the first steps, which then lead to the development of a site conceptual model (SCM). A systems-based assessment follows the SCM, which includes the remedial investigation, assessment of risk and appropriate end states, and revision of the SCM if necessary. The site then moves into a systems-based monitoring phase, during which the remedial strategy is completed and an alternative end state is selected if needed. In selecting an end state, risk needs to be evaluated at multiple levels and integrated for a holistic view. Current needs and drivers should be balanced with future land use, site managers should be cognizant of costs saved versus risk reduced should be evaluated, and site managers should consider whether there are high-consequence hazards where risk is too great.

An alternative end state is not a ‘walk away’ approach, an easy or quick fix, un-protective of human health and the environment, or rigid and inflexible. Rather, it requires long-term management to address residual contamination and employ new technologies and approaches as they become available. In addition, an alternative end state is based on robust, holistic SCMs that provide platform for more accurate predictions and risk-informed decisions, considers all aspects of risk and is re-evaluated within context of resource-use goals or other significant changes in model assumptions, and is an iterative approach that provides transition of sites from active remediation or intensive characterization and monitoring into systems-based long-term monitoring strategies.

Multiple opportunities are available to help overcome remediation challenges, particularly with regard to alternative end states. It is important to examine what has been done at other sites, evaluate lessons learned, gain interagency collaboration, attain regulatory and stakeholder engagement, make risk-informed and defensible decisions, robustly manage residual contamination in the long-term, and transfer technology and expertise. Various resources are available for technology transfer, including EPA guidance documents, *Cleaning Up the Nation’s Waste Sites: Markets and Technology Trends*, EPA 542-R-04-015, ITRC overview document and training, Navy Alternative Restoration Technology Team workgroup, AFCEE and Army initiatives, and the ESTCP Alternative Endpoints and Approaches for groundwater Remediation document.

Question: Have you worked on sites where the remediation system has been in operation and is then optimized by increasing the scope of the remedy? The key point is optimization by increasing the remedy scope.

Answer: The Test Area North Site is an example of alternative end states. The site is contaminated with TCE and radionuclides and contains a 3-mile long plume. In situ bioremediation and pump-and-treat were applied to the source area. The pump-and-treat system was optimized by installing new extraction and injection wells closer to source area. This helped address source area radionuclides. In addition, the pumping was changed. In 10 years, rebound tests were completed and the pump-and-treat system was shut down. The same type of strategy was employed for the in situ bioremediation treatment. The distal portion of the plume initially was not treated, but is now undergoing MNA.

Question: How would you like to see the interagency collaboration proceed?
Answer: I hope that in the next six months to a year, a representative from each agency and/or branch present at this meeting can begin a collaborative discussion regarding the most logical path forward. Dozens of case studies exist where alternative end states worked very well. It will be important to work with EPA to establish alternative end states acceptable from the regulatory perspective. The most important task is opening the door to the conversation and having a 'buy in' from all those invested with regard to the way we want to move forward.

Comments: Skip Chamberlain commented that an interagency team to develop these tools to reach these end states would be an important aspect of the collaborative effort. FRTR could potentially be used as a medium for sharing the tools that have been developed to address these complex sites. Tom Nicholson suggested that analytic capability is the missing part of this strategy. Skip replied that one of the issues and tasks for the futures is conducting a complexity analysis.

Cleanup of Contaminated Sites: Overview of End States, Challenges and Opportunities: An Army Perspective

Laurie Haines, U.S. Army Environmental Command (AEC), stated that AEC's mission is to lead and execute environmental programs and provide expertise that enables Army training, operations, acquisition and sustainable military communities. The Department of Defense's goals for the Cleanup program is to attain a Response Complete (cleanup goal met and currently monitoring) status at 90% of Installation Restoration Program (IRP) and Military Munitions Response Program (MMRP) sites by 2018, and a Response Complete status at 95% of IRP and MMRP sites by 2021.

AEC has recently implemented several initiatives, including conducting independent technical reviews that identified technical impracticability as a likely end state at sites with complex hydrogeology and DNAPL, completing several internal reports on technical impracticability, and funding two National Research Council (NRC) studies, including the study that led to the 2012 report on *Contaminants in the Subsurface* and *Alternatives for Managing the Nation's Complex Contaminated Groundwater Sites* (http://dels.nas.edu/Report/Alternatives-Managing-Nation/14668). A series of questions comprised the statement of task for the latter study, which considered both public and private hazardous waste sites: (1) Size of Problem – at how many sites does residual contamination remain such that site closure is not yet possible? At what percentage of these sites does residual contamination in groundwater threaten public water systems? (2) Current Capabilities to Remove Contamination – What is technically feasible in terms of removing a certain percentage of the total contaminant mass? What percent removal would be needed to reach unrestricted use or to be able to extract and treat groundwater for potable reuse? What should be the definition of "to the extent practicable" when discussing contaminant mass removal? (3) Correlating Source Removal with Risks – How can progress of source remediation be measured to best correlate with site-specific risks? Recognizing the long-term nature of many problems, what near-term endpoints for remediation might be established? Are there regulatory barriers that make it impossible to close sites even when the site-specific risk is negligible and can they be overcome? (4) The Future of Treatment Technologies – The intractable nature of subsurface contamination suggests the need to discourage future contaminant releases, encourage the use of innovative and multiple technologies, modify remedies when new information becomes available, and clean up sites sustainably. What progress has been made in these areas and what additional research is needed? (5) Better Decision Making – Can adaptive site management lead to better decisions about how to spend limited resources while taking into consideration the concerns of stakeholders? Should life cycle assessment become a standard component of the decision process? How can a greater understanding of the limited current (but not necessarily future) potential to restore groundwater be communicated to the public?

Question: Is the U.S. Army on track to meet the 2018 and 2021 goals?
Answer: I believe we are close, but much work remains for the goals to be achieved.

LUNCH-FACILITATED DISCUSSION

A facilitated discussion on the Spring 2013 FRTR meeting topic was held during lunchtime. Greg Gervais provided the group with a list of past meeting topics that could potentially be used for the Spring 2013 meeting. Potential topics included environmental footprints, sediments, ecological revitalization and reuse, bioremediation advances, and heavy metals: site issues and solutions. The steering committee will decide the spring 2013 FRTR meeting topic during its meeting on November 15, based on participant suggestions. One meeting topic suggestion made by the participants was risk-based decision-making. Other suggestions included the impact of climate change on cleanup goals, and a meeting consisting of case studies on complex sites with a discussion on how challenges were overcome. Kim Brown proposed holding a meeting on the subject of munitions. Carol Dona suggested that the munitions subject could be expanded to MMRP sites. She added that choosing green and sustainable remediation as a topic could span over many subject areas, including the topic of the previous FRTR meeting on large and dilute plumes. Sam Brock expressed his interest in the topic of emerging contaminants. Kim Brown agreed with Sam Brock's comment on emerging contaminants and added that Andrea Leeson (ESTCP) suggested this topic as well.

CASE STUDIES

EPA Case Study – Use of Mass Discharge as a Performance Metric in CERCLA Decision Documents: Case Study of the Time Oil Well 12A Site

Rene Fuentes, EPA Region 10, discussed how mass flux or discharge goals can be incorporated into long-term plume management strategies with the ultimate goal of meeting MCLs, using the Time Oil Well 12A site as a case study. Rene stated that many CERCLA decision documents for DNAPL site remediation lack clear remedial action objectives for determining and documenting when sufficient source treatment has been completed. Mass flux or discharge can be used to document when source treatment is considered "complete" and long-term groundwater restoration projects considered operational and functional.

The Time Oil Well 12A site is located in Takoma, Washington. The site is located over a major aquifer used by the City of Tacoma for its water supply. Six contaminants of concern were identified in soil and groundwater: tetrachloroethene, TCE (ubiquitous), *cis*-1,2 DCE, *trans*-1,2 DCE, vinyl chloride, and 1,1,2,2-tetrachloroethane. Historic remediation activities included a groundwater extraction system, which operated onsite from 1988 to 2001 and removed 16,000 pounds of VOCs from groundwater, a vapor extraction system that operated from 1993 to 1997 and removed 54,100 pounds of VOCs from the unsaturated zone, and completion of a filter cake and contaminated soil removal, which resulted in the excavation of 1,200 cubic yards of soil and removal of 5,000 cubic yards of filter cake.

The desired end state for the site included adequate use of robust source removal technologies for the source area, timely transition to cost-effective 'polishing' steps, reduction or elimination of the need for pump-and-treat, appropriate reliance on MNA, and adaptive and flexible implementation. Results of a focused feasibility study indicated that reducing source strength by 90% and using MNA as a polishing step would be sufficient to achieve compliance. The subsequent goal was to introduce a multi-component remedy into a ROD Amendment to reduce the source discharge strength by 90% and transition the technology if necessary.

Site characterization was completed by installing over 34 soil borings to reduce uncertainty and delineate sources, conducting a vertical profile assessment at 12 locations, collecting depth-discrete samples (groundwater, soil, slug testing, stratigraphy), and conducting a gradient assessment. A vertical soil profile characterization showed that the fine-grained silt layer (50 feet below ground surface) remained highly contaminated. A three-dimensional cross-section of the contaminant plume also revealed high levels of contamination at the base soil layer at a location not immediately underneath the building.

The challenges associated with estimating mass discharge at the site included the need to assess impacts from secondary sources, residual phase contaminants, and back diffusion from low-permeability layers; managing complex hydraulics, including substantial changes in gradient magnitude and direction due to seasonal variations and operation of Well 12A; and obtaining realistic parameters such as porosity and hydraulic conductivity within vertically-discrete zones within the contaminant plume. Mass discharge was calculated using two methods: a transect model and a pumping method. The transect model involved the following steps: (1) Drawing polygons; (2) Calculating Darcy velocity (q) for each polygon: q=K x I; (3) Characterizing polygon flux (Mf=q x C_n); (4) Determining area (W x B = A); (5) Evaluating mass discharge (M_d $=\Sigma$ (M_f x A_n)) where M_f refers to mass flux, M_d refers to mass discharge, C_n refers to the concentration in polygon n, and A_n refers to the area of segment n. The pumping test was conducted using screens at 50-70 feet below ground surface, and was associated with multiple uncertainties, including pumping-induced changes to the natural flow regime, impacts of secondary sources on mass discharge assumptions, and increased gradients through significant contaminant sources. The next steps in the process include determining if additional field data is needed to evaluate mass discharge methods, picking a mass discharge measurement method, measuring baseline mass discharge, and implementing in situ thermal and enhanced bioremediation actions to achieve mass discharge reduction goals.

Based on the results of the mass discharge calculations, it was concluded that mass flux and mass discharge can improve management of complex contaminated sites and new technologies are increasing the confidence in these metrics. In addition, the use of new technologies has significantly improved remedial decision-making in developing, designing, and implementing remedial actions. In the future, the Well 12A site will be used as a case study in how to use these approaches under the Superfund regulatory framework.

Question: You mentioned that the use of new technologies has significantly improved the decision-making process. Can you list several of the new technologies you are referring to?
Answer: Some of the things that helped with the decision-making process included: (1) The ability to sample water and soil in multiple locations within a shorter time frame; (2) The ability to sample via pumping and obtain laboratory results quickly so that decisions regarding continuing to operate wells or shutting wells down could be made promptly; (3) Certain actions (e.g., removing a rail car) can be completed faster with the availability of modern amenities.

DOE Case Studies – End States for Vadose Zone Environments

Mike Truex, PNNL, presented case study examples examining approaches and tools for selection of protective remediation end states for contaminants in the vadose zone. The generalized conceptual model for end state assessment suggests that at an end state, contaminants remaining in the subsurface must not pose a risk. Soil vapor extraction (SVE) effectively removes contaminant vapors, but typically cannot remove all of the contaminant mass. It is necessary to evaluate, then, whether contaminants that remain after a period of SVE operation pose a risk. To do so, it is important to determine how strong the source is and find the location of the persistent source. Data from the SVE system can be used to quantify source strength as contaminant mass discharge. This can be done by cycling SVE system operation and switching it on and off. Contamination discharging from source areas causes concentrations to ‘rebound’ while the system is off. Analyzing this rebound concentration provides an estimate of source strength if the SVE system is terminated, which can be used to evaluate whether the source poses a risk.

An SVE system can also be used to find the location of the contaminant mass in relation to receptors. For example, at the Hanford site, the groundwater is contaminated by sources other than the vadose zone and is being treated by pump-and-treat. The SVE system needs to have reduced vadose zone contamination such that groundwater remediation goals can be met within timeframe of groundwater remedy. As a result, an assessment was completed to determine future impacts of SVE termination; the findings were incorporated into the site ROD. The DOE *Soil Vapor Extraction System Optimization, Transition, and Closure Guidance* (in EPA clearance review) provides a systems-based approach to SVE performance assessment and estimating closure conditions.

In the vadose zone, contaminants are a potential risk to groundwater even if they do not pose a direct exposure threat. Transport of contaminants in the vadose zone is significantly attenuated by hydraulic processes and dispersion in addition to potential geochemical attenuation. Thus, natural attenuation can likely be a significant part of mitigating risk. When natural attenuation is only part of the remedy, the MNA analysis can identify enhancements to attenuation processes that reduce flux to groundwater.

At the Hanford 300 area, uranium waste solutions were being discharged at the ground surface. The uranium plume was adjacent to Columbia River. The initial remedial investigation and feasibility study led to excavation of waste trenches and MNA for the groundwater plume, under the assumption that the uranium source could be removed with excavation. However, monitoring showed that the plume did not decline as expected and a subsequent remedial investigation and re-evaluation of the CSM were completed. The investigation revealed that a uranium source was present in the lower vadose zone, and was affected by seasonal water table rise. An evaluation of the remedy suggested that there were few viable source treatment options available due to the site's complexity and size. The Hanford 300 area is still undergoing treatment. When determining end states protective of groundwater at complex sites such as the Hanford 300 site, it is important to use structured methods to examine data, develop conceptual site models, and use the information in those models supply to conduct appropriate analyses set by end states.

Question: How do you satisfy people's concerns regarding extreme events, such as flooding, in your models?
Answer: The first step is to develop a conceptual site model. After the conceptual site model is complete, sensitivity analyses can be conducted. This information would then be provided to decision-makers.

Air Force Case Study – Complex Remediation at Air Force Plant PJKS

Sam Brock, AFCEC, described a success story about how project managers identified key technical challenges and evaluated and mitigated the impact of these challenges on the remedial strategy. The Air Force Plant PJKS site is located in Littleton, Colorado. It has been used as a fuel test/development facility since 1957. The Air Force, with EPA and the Colorado Department of Public Health and Environment (CDPHE) oversight, has been conducting an environmental investigation at PJKS focused on soil and groundwater contamination since the late 1980s. Past investigations identified 53 contaminated soil sites, all of which have now been addressed and closed. Thirty six have been closed without restriction, 12 have been closed with restriction and five have been closed with restriction plus limited cover. The remaining contaminants of concern – TCE and N-nitrosodimethylamine (NDMA) – are located in the three groundwater plumes with associated bedrock source areas, which are comprised of fractured sandstone and fractured crystalline rock. Both TCE and NDMA plume boundaries are stable (NDMA plume boundaries are located within TCE plume boundaries) and vapor intrusion is not a significant concern.

Several ITRC guidance documents as well as the *Groundwater Road Map: Recommended Process for Restoring Contaminated Groundwater at Superfund Sites*, OSWER 9283.1-34, July, 2011 were consulted in setting remedial objectives and selecting remedies for the site. The main concern in choosing a remedy was having a reasonable opportunity for success in a complex situation and managing risk. The first step to choosing a remedy that addressed this concern was identifying the contaminant-related, hydrogeologic, and other challenges. In addition, the likelihood of technical cleanup challenges were evaluated by conducting technology performance assessments (pilot- or full-scale), site data assessments, and integrating assessment results into the CSM. Potential adverse impacts of technical cleanup challenges such as noncompliance with regulations, long-term property restrictions, and litigation, were also considered.

Several pilot studies were conducted at the site. The first study used enhanced bioremediation, which worked fairly well and reduced TCE concentrations from 12,000 μg/L to 25 μg/L in one area at the site. Enhanced bioremediation was not effective at reducing NDMA, however. Another pilot study was then conducted to address NDMA concentrations using ex situ nickel hydrogen treatment. The technology was determined to be not scalable. Pump-and-treat was considered as a viable option, but the 100-year cleanup timeframe under pump-and-treat was determined to be inadequate.

The U.S. Air Force, EPA, and CDPHE established preliminary remedial action objectives (RAOs) for groundwater at PJKS in December 2005. The RAOs for TCE at the PJKS site were to reduce TCE contamination at the transition points (where bedrock groundwater transitions into the alluvial system) and reduce TCE concentrations in bedrock source areas to levels that achieve Colorado Basic Standards for Groundwater for groundwater beyond the PJKS point of compliance. The maximum effect of the technologies used to address contamination was projected to be achieved in approximately 10-20 years, considering uncertainty about response to in-situ treatment. The RAOs for NDMA were to protect human health by preventing contact with, and ingestion of, TCE or NDMA contaminated groundwater until unlimited use/unrestricted exposure levels are achieved, contain NDMA in the alluvium through the continued monitoring of the plume stability until the groundwater is remediated to beneficial use, except where a waiver is justified based on technical impracticability, and to utilize a TI Waiver for restoring NDMA within bedrock groundwater in a reasonable timeframe.

Remedial actions proposed for addressing TCE were In-situ bioremediation with environmental covenant, a TI Waiver with environmental covenant selected for NDMA in contaminated bedrock groundwater, and to operate and maintain interim groundwater remedial actions.
The carbon source was installed using vertical and horizontal wells and temporary injection points. A biobarrier installation was completed at the bedrock/alluvium transition. The goal was to achieve an asymptotic state of contaminant concentrations or attain remedial action standards. The operation and maintenance plan called for system shutdown, rebound testing, and appropriate adjustments when an asymptotic contaminant levels were reached.

CDPHE approved a TI Waiver for restoring NDMA within bedrock groundwater in a reasonable timeframe. The basis for the waiver was a large volume of NDMA in contaminated bedrock, poor bedrock permeability and inability to access contaminated groundwater (rendering pump-and-treat impracticable), and fractured bedrock with unpredictable flow characteristics and associated matrix back diffusion. The treatment, then, consisted of containing NDMA in alluvium through monitoring of the plume. This treatment did not require a physical remedial system.

The treatment for groundwater at this site is an example of adaptive site management. Adaptive site management techniques included implementation of environmental covenants to ensure protectiveness, selection of alternate points of compliance, implementation of innovative technologies (e.g., using propane or methane for nutrient supplementation), and employment of the treatment train concept (remediation of TCE to reduce inhibition of NDMA bioremediation, followed by nutrient supplement tailored to NDMA). The U.S. Air Force, regulators, and property owners worked together to establish sustainable remedies. Reasonable judgments were made as a team, using simple assessments and appropriate tools, focusing on the long-term, implementation of phased approaches, and agreeing collectively to curtail spending on impracticable remediation techniques.

Question: How were you so successful in facilitating cooperation within your team?
Answer: Some teams are more effective and productive than others. Effective teams tend to move forward at a steady pace. In this case, everyone on the team contributed by focusing on practicable solutions.

Question: What were the human health receptors, what was the cost up to where you are today, and how long have you been working to get to this point?
Answer: The human receptors were offsite residents and onsite workers. There is no groundwater use at the site and no connection between groundwater and surface water; therefore, there are no ecological receptors at the site. Investigation began in the early 1990s and has been ongoing for about 10 years. Investigation, interim actions, and several pilot studies cost approximately $15 million. However, this is significantly less than the cost that would have been incurred using pump and treat (estimated at $130 million).

Question: A significant amount of work had been put in onsite before a TI Waiver was considered. What was the rationale behind classifying the TI Waiver as an upfront waiver?
Answer: The TI Waiver was received before the ROD was signed. The significant amount of engineering work done prior to obtaining the TI Waiver gave us a deep understanding of site characteristics, which allowed us to provide a rational explanation for seeking a TI Waiver.

Navy Case Study – An Alternative Approach at a Hydrogeological Complex Site Contaminated with Chlorinated Compounds

James Tarr, NAVFAC Mid-Atlantic, provided an overview of the basis for obtaining a TI Waiver and presented a case study of a site in Mechanicsburg, Pennsylvania. Numerous factors can inhibit groundwater restoration, including complex hydrogeology and sedimentary deposits, low-permeability aquifers, certain types of fractured bedrock, and contaminant-related challenges. Sites with TI Waiver determinations typically have fractured bedrock, where it is nearly impossible to intercept and capture contamination at all fractures and openings. DNAPL is often found at sites with TI Waivers, because it is difficult to locate and capture due to its ability to sink to the bottom and move to deeper areas of the aquifer. However, presence of DNAPL or fractured bedrock is not sufficient to justify a TI Waiver determination. The TI Waiver determination needs to be made on a contaminant and media-specific basis for cleanup standards contaminant-media.

The NSA Mechanicsburg, Pennsylvania site was placed on the NPL in 1994. From the 1940s until 1977, site 3 (burn pits 1 and 2) was used for disposal of liquid wastes. Soil and groundwater at the site were contaminated with chlorinated VOCs. Dye tracer testing was used to confirm flow through karst conduits. A removal action was performed in the mid to late 1990s, which involved excavation of burn pits and offsite disposal of 47,000 tons of source material down to bedrock surface. A post-removal site ROD signed in 2000 consisted of institutional controls, primarily land use restrictions. A 2004 groundwater ROD called for prevention of exposure to contaminants by preventing migration of contaminants in groundwater to surface water, treating and controlling free and residual product (unless technically impracticable), and required the site to meet Preliminary Remediation Goals (PRGs) and MCLs. The remedial approach selected in the ROD included land use controls, in-situ chemical oxidation (ISCO) using hydrogen peroxide/chelated iron catalyst at 40 injection points in the source areas at multiple depth, and post-injection monitoring. In 2004, the U.S. Navy implemented two phases (four rounds) of ISCO, injecting 194,071 gallons of oxidant. Subsequent sampling data indicated the plume was stable and under Navy control within NSA Mechanicsburg boundaries.

Despite soil removal and an aggressive ISCO program, significant contaminant levels remain. Short-term spikes in concentrations after drilling activities suggested that pockets of non-aqueous phase liquid (NAPL) were still present in deep portions of the aquifer. Some contamination is inaccessible, located in tight, dead- end fractures, and has diffused into the rock matrix in the deep aquifer. A long-term groundwater monitoring program has been in place since 2004, which requires sampling of selected wells, groundwater flow evaluation, and contaminant trend analysis. Due to the persistent presence of VOCs at levels above cleanup goals, the site team is working toward obtaining a post-implementation TI Waiver for deep groundwater. A TI Waiver would waive the timeframe for attaining cleanup levels without eliminating the need for plume containment. Several site factors support the attainment of a TI Waiver: complex hydrogeology (folded/faulted rock), tightly fractured bedrock at depths greater than 3000 feet below ground surface (limiting contaminant accessibility), historical and current presence of NAPL, persistence of contamination in source areas despite aggressive in situ treatment, matrix diffusion, and projected cleanup timeframe beyond the ROD estimate of 10 years. In addition, data show stable plume footprints and a lack of sensitive receptors.

A meeting was held by the partnering team in 2011 to identify issues and remaining data gaps, and to identify the potential path forward. The team decided that additional deep wells are needed around one of the former burn pits and additional water level data is needed to better understand groundwater flow patterns. MNA outside the TI zone through a ROD Amendment and a post-implementation TI Waiver for the deep groundwater portion of the aquifer, were identified as the potential steps for the path forward at the site. This alternative endpoint recognizes the remedy most practical based on scientific investigation. In the fall of 2012, the partnering team plans to submit an annual monitoring and an annual water level study report for Site 3. A TI Waiver Evaluation Report is planned for submission in late 2012 or early 2013 and a ROD Amendment is expected to be issued in 2013. Groundwater monitoring at the site is ongoing and land use controls remain in place. The site continues to undergo five-year reviews.

Question: How did you decide how much chemical oxidant to inject and when to stop the injections?
Answer: ISCO implementation was based on many background analyses, including resistivity, packer analysis, and other studies.

PANEL DISCUSSION

Recap of Key Technical Challenges and Identifying Opportunities for Future Collaboration

Kate Garufi noted that the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) define the context under which EPA must operate and make decisions regarding endpoints. She added that it has been beneficial for EPA to learn about endpoints from a technological perspective.

Rula Deeb, ARCADIS, clarified the definition of end state and endpoint. She defined end state as the condition of the site once the remedy is complete, and an endpoint as a component of the overall remedy to achieve the desired end state. She clarified that the purpose of the meeting is not to discuss alternative end states but rather alternative endpoints to achieve the desired end states.

Anna Willett, ITRC Director, provided an overview of ITRC's mission and presented the results of a 2008-2009 survey conducted by ITRC regarding project risk management for site remediation. Thirty-one states responded to the survey; at least 24 answers were received for each question. One of the questions posed was what options are considered if the selected remedy is not on track to meet remedial objectives. The options receiving the greatest responses (17 responses each) were land use controls or institutional controls, long-term monitoring, and MNA. Alternative cleanup limits, additional modeling, and TI waivers received nine responses each, while the least selected options were mixing zones, combinations, moving the compliance point, and extending time to completion. Responders considered alternatives for complex sites where some areas may not have been impacted, a combination of technologies and actions might be required to address all exposure pathways, and other scenarios. Full survey results are available at: www.itrcweb.org/Documents/RRM-1.pdf. Many survey responders also agreed that a document on how to conduct a technical assessment on whether a remedy will meet remedial objectives would be useful. Much opportunity exists for interagency dialogue.

Sam Brock stated that the U.S. Air Force's performance remediation goal is to accelerate completion of 50% of all sites by FY 2012 and 75% by FY 2015. The key objectives are to meet the DOD goal of attaining a Response Complete status at 90% of all cleanup sites by FY 2018 and 95% by FY 2021. The DOD is facing numerous challenges to achieving these goals, such as emerging contaminants and future financial uncertainties. However, opportunities for overcoming these challenges exist and include implementing aggressive surveillance programs, implementing guidance on assessing emerging contaminants, prioritizing and tracking critical data management system improvements, developing and tracking performance measures, and tracking complex site life cycle costs. An FRTR subgroup could assist with these efforts by developing performance models and a decision logic consensus document.

Laurie Haines stated that better tools for decision-making are needed. These tools need to be more quantitative than the tools currently available, to ensure a less subjective process and better assist in making good and quick decisions.

Kim Brown discussed the Department of the Navy's approach to managing risk at groundwater sites. Risk management can be used to determine if a site needs remedial action, and if it is technically feasible to achieve the cleanup goals at a site. The Department of the Navy manages for both the U.S. Navy and the U.S. Marine Corps. The challenging sites generally have large, low concentration plumes, deep alluvial aquifers with fractured bedrock, or low permeability formations, matrix diffusion, and DNAPL. A basic Navy toolbox approach is available for addressing these sites, which emphasizes conducting site evaluations and developing a CSM, risk management, remediation strategies, such as treatment trains and MNA as a polishing technology, optimization/sustainability, and the use of new tools, such as mass flux and plume stability/MNA software. The U.S. Navy also focuses on performance objectives, which need to be developed and clearly defined, and exit strategies which identify when to stop, modify, or change the technology, and identify the appropriate times to transition to other components of the treatment train. The overarching goals are to select a remediation approach to achieve an objective and to define a clear endpoint.

Typical alternative approaches to groundwater remediation include groundwater plume management and treatment as well as MNA over long timeframes, TI Waivers, and adaptive site management. Key references are the NAVFAC Groundwater Risk Management Handbook (2008), Guidance for Optimizing Remedy Evaluation, Selection and Design (2010), and the Navy Optimization Policy (2012). These documents can be found through https://portal.navfac.navy.mil/go/erb. Opportunities for collaboration include working collectively on decision-making tools and identifying approaches to adaptive site management.

Skip Chamberlain said that the DOE is looking toward collaborating on numerous tools. He suggested that an interagency team that would put forth proposals to ITRC would be useful. Other opportunities for collaboration include developing cost and performance reports, involving the research community, identifying approaches to sites with co-contaminant mixtures, streamlining existing approaches, better communicating available tools to regions, working together on modeling, and developing new processes and tools as a team with other agencies to help reduce costs.

IDENTIFYING OPPORTUNITIES FOR FUTURE COLLABORATION: ACTIONABLE ITEMS

- Development of tools for decision-making. Current tool needs:
  - More quantitative tools than currently available.
  - Less subjective process.
- Better collaboration on tools and approaches (such as adaptive site management) for decision-making.
- Formation of an interagency team. Examples of team activities:
  - Outreach to the research community.
  - Collaborative writing and submission of grant proposals to funding agencies.
  - Working together with ITRC. For example, the ITRC and interagency team could together co-fund the formation of a group. The group's work would parallel that of the interagency team in developing decision-making tools.
  - Working together with the Federal Interagency Steering Committee on Multimedia Environmental Modeling.
- Streamlining the approach to addressing risk at sites with contaminant mixtures and better communicating the tools available to address risk to regional staff.

- Development of cost and performance reports that would identify lessons learned.
- Utilization of resources, such as ESTCP and SERDP, to assist with the remediation decision-making process, including when an alternative approach to remediation (for example, adaptive site management using an iterative approach) is needed.
- Discussion on risk and acceptable risk management from both technical and policy perspectives, to strengthen the interface between policy and the technical/scientific perspective and facilitate moving forward with decision-making.
- Creation of opportunities in the future to discuss policy from a technical perspective.
- Clarification of the language and terminology. A clear definition of terms and consistent use of precise language is needed to achieve results and move forward.
- Ensuring more effective, efficient, appropriate, and consistent use of existing technologies and tools. Potential approaches:
  - Categorization and grouping of existing tools and approaches applicable to certain situations and activities (for example, tools available for mass flux analysis). Holding a discussion on this topic in the future may be valuable.
  - Development of a standard of practice to ensure that currently available tools are used consistently and effectively. This would be followed by identifying data gaps to determine the new tools or methods needed to address site challenges.
  - Maintaining the [FRTR Remediation Technologies Screening] matrix; adding new technologies to the matrix.
- Development of new tools and technologies, such as tools for modeling and long-term monitoring.
- Influencing research efforts to facilitate placement of new technologies into the market (for example, determining the status of research efforts on new technologies at national laboratories).
- Broader thinking about innovation.
- Development of a better definition of an "acceptable timeframe."
- Closing the gaps on cleanup approaches available for addressing mining sites and contaminated sediments.
- Discussion on approaches to leveraging performance measure data. This can facilitate a better understanding of obstacles encountered during cleanup (for example, whether the cleanup obstacle is technology performance or lack of contact between the technology and the target).

Those interested in participating in a subgroup that would work on aspects of end states should e-mail Jessica Burns, Environmental Management Support, at jessica.burns@emsus.com. She will then send the actionable items list to the individuals interested in participating in the subgroup. A call with interested participants will likely be set up after Thanksgiving.

ATTACHMENTS

A. Overview of End States: Groundwater Remediation, Management and the Use of Alternative Endpoints at Highly Complex Sites
B. EPA Groundwater Expectations: An Overview of CERCLA, the NCP, and EPA Policy and Guidance for Superfund Groundwater Response Actions
C. Defense Environmental Restoration Program Overview of Challenges and Opportunities
D. A Perspective on DOE Challenges and Opportunities for Alternative End States

E. Cleanup of Contaminated Sites: Overview of End States, Challenges and Opportunities? An Army Perspective
F. EPA Case Study—Use of Mass Discharge as a Performance Metric in CERCLA Decision Documents: Case Study of the Time Oil Well 12A Site
G. DOE Case Study—End States for Vadose Zone Environments
H. Air Force Case Study—Complex Remediation at Air Force Plant PJKS
I. Navy Case Study—An Alternative Approach at a Hydrogeological Complex Site Contaminated with Chlorinated Compounds