

**U.S. ARMY
ENVIRONMENTAL
CENTER**

U.S. ARMY ENVIRONMENTAL CENTER

**POLLUTION
PREVENTION
&
ENVIRONMENTAL
TECHNOLOGY
DIVISION**

Innovative Technology Demonstration, Evaluation and Transfer Activities



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This report describes current endeavors at the U.S. Army Environmental Center's (USAEC's) Pollution Prevention and Environmental Technology Division (P2&ETD) during fiscal year (FY) 1999. These project summaries will help readers to better understand the division's efforts and capabilities.

Technology is a major weapon in the Army's efforts to both defend the nation and sustain its environment. Through the programs described in this report, USAEC gives the Army access to the most effective and affordable environmental tools available.

P2&ETD maintains its focus on conservation, pollution prevention, compliance and cleanup technologies, bolstering the Center's commitment to saving money and quickly putting innovative ideas to work for its Army and Defense Department customers.

WHAT'S INSIDE?

The FY 1999 P2&ETD Annual Report is organized by the following categories:

- Pollution Prevention Programs
- Environmental Technology Programs
- Cleanup Technology
- Compliance Technology
- Pollution Prevention Technology
- Conservation Technology
- Program Focus: Range XXI
- Other Technology Programs
- Appendices

Project descriptions are organized into several sections:

PURPOSE

What problem does the project address?

BENEFITS

How does the project help its users?

TECHNOLOGY USERS

Who will use the technology?

DESCRIPTION

Why develop such a technology? How does it work? What is the development approach?

ACCOMPLISHMENTS AND RESULTS

So far, what results have been achieved?

LIMITATIONS

What might affect the use of this technology?

FOLLOW-ON PROGRAM REQUIREMENTS

What additional requirements are anticipated?



POINT OF CONTACT

Whom do I contact for more information?

PROGRAM PARTNERS

What organizations are participating in the project?
(Appendix B contains a consolidated list of partners.)

PUBLICATIONS

What publications relate to the project?

(Section headings that do not apply to the project are omitted.)

FOR MORE INFORMATION

Want to know more about USAEC pollution prevention and environmental technology projects?

WRITE to t2hotline@aec.apgea.army.mil

CALL the Army Environmental Hotline at (800) USA-3845.

VISIT the USAEC Web site at <http://aec.army.mil/>



P2&ETD program teams support initiatives to merge pollution prevention into Army missions, such as aiding efforts to buy and use materials that don't pollute the environment; integrating pollution prevention practices into training; fielding systems and methods to manage hazardous materials and reduce generation of hazardous waste; helping major commands and installations prepare and pay for P2 plans; and partnering with state and federal regulatory officials.



◆ AFFIRMATIVE PROCUREMENT

The Army needs various awareness vehicles to comply with Affirmative Procurement requirements mandated by federal laws, regulations and executive orders. The Affirmative Procurement awareness program will show the Army how to reduce solid waste, energy consumption, toxic materials and raw material usage – while stimulating the market for recycled-content products and encouraging use of new technologies.

PURPOSE

To establish and advance the acquisition and use of environmentally preferable products and services; to implement preference programs among the Army's requirements community; and to reduce the Army's solid waste stream.

BENEFITS

This program benefits both the Department of Defense (DoD) mission and the environment. It created the framework to reduce solid waste, energy consumption, and usage of toxic and raw materials. Reducing the use of toxic materials lessens effects on human health and the environment while decreasing the Army's hazardous waste stream. Affirmative Procurement stimulates the market for recycled-content products and encourages development of new technologies, quality products and services.

TECHNOLOGY USERS

All facets of the DoD community, including technical/requirements generators, procurement personnel, environmental offices, buyers, industry and education personnel.

DESCRIPTION

Although program requirements are changing and expanding through Executive Order (EO) 13101 – which replaced EO 12873 – the requirement for an Affirmative Procurement program that includes reporting existed under Section 6002 of the Resource Conservation and Recovery Act (RCRA), the Solid Waste Disposal Act of 1976. The EO establishes implementation procedures for RCRA and directs federal agencies and their contractors to purchase recycled content and environmentally preferable products (EPP) and services; review and revise federal and military specifications to enhance EPP purchasing; and consider environmental attributes (elimination of raw materials, waste minimization and prevention, toxicity reduction or elimination) in acquisition planning.

To date, the Environmental Protection Agency (EPA) has designated 36 Affirmative Procurement items and their standards for federal purchasing. More are being proposed for inclusion. The Comprehensive Procurement Guidelines categories are paper, nonpaper products, vehicles, construction, transportation, parks and recreation, and landscaping. The Recovered Material Advisory Notice denotes each item and its minimum recovered-material content set by the EPA.

Affirmative Procurement is also codified in the Federal Acquisition Regulation. Army Regulation 200-1 places the Affirmative Procurement program under the scope of pollution prevention.



ACCOMPLISHMENTS AND RESULTS

As part of the awareness campaign, an Affirmative Procurement Web page was created in the second quarter of fiscal year 1998. This Web page is structured to access relevant memoranda, the latest information on designated items, ordering and purchasing information, vendor and manufacturer sources, recommendations for successful word searches, and related training and conferences. An Army program brief and fact sheet are available for downloading. The U.S. Army Environmental Center (USAEC) was part of a regional EPA pilot program for environmentally preferable purchasing. Many organizations, including Army major commands, EPA regions and the Professional Housing Manager's Association, have requested USAEC's assistance for FY 2000 and beyond. This program received honorable mention in the White House Closing the Circle Awards.

Platform presentations were given at three joint-service conferences: the National Recycling Coalition and the National Marketplace for the Environment; the National Defense Industrial Association (NDIA) Joint Service Environmental Conference and NDIA Joint Service P2 Conference National Marketplace for the Environment; and the U.S. Department of Agriculture and Bio-based community, National P2 Roundtable. USAEC also delivered a joint presentation with the Defense Logistics Agency on re-refined oil and closed-loop recycling to the Army Training Center.

USAEC developed a fact sheet that describes the program and lists the current EPA-designated items. Articles were submitted for publication to various magazines.

FOLLOW-ON PROGRAM REQUIREMENTS

- Track program changes under EO 13101 and disseminate this information to the field through presentations, workshops, Web page updates, articles and fact sheets.
- Develop outreach products, including an Army Program Guide and a tabletop display of recycled-content products with statistics on solid-waste reduction.
- Provide Affirmative Procurement expertise – through workshops and presentations – to requesting organizations in FY 2000.

PROGRAM PARTNERS

U.S. Army Environmental Center
Office of the Director of Environmental Programs

POINT OF CONTACT

Doenee Moscato

PUBLICATIONS

"Army 'Buys Green' to Prevent Pollution." *Environmental Update*. Summer 1998.

U.S. Army Environmental Center. *Fielding Environmental Solutions* (electronic mailing list). 1998.

National Defense Magazine. 1998.

DPW Digest. 1998.



◆ **EMERGENCY PLANNING AND COMMUNITY
RIGHT-TO-KNOW ASSISTANCE**

Department of Defense (DoD) installations will begin reporting munitions-demilitarization activities under the Emergency Planning and Community Right-to-Know Act (EPCRA) on July 1, 2000. This project seeks to collect and place information on certain EPCRA toxic chemicals into a software package for installation use.

PURPOSE

To develop technical guidance for EPCRA reporting.

BENEFITS

Cost-effective and consistent EPCRA reporting.

TECHNOLOGY USERS

Army and DoD installations.

DESCRIPTION

DoD has required EPCRA reporting of munitions-demilitarization activities beginning July 1, 2000. This project seeks to identify EPCRA toxic chemicals in munitions and those released by munitions-demilitarization activities, and package this information in a software data-delivery system for installation use.

This effort is jointly funded by the Army, Air Force, Navy, Marine Corps and Deputy Under Secretary of Defense for Environmental Security.

ACCOMPLISHMENTS AND RESULTS

The Range XXI program is developing accurate emissions data. Literature research and software evaluations are complete; designing and populating of the database are underway.

The software was beta-tested during summer 1999.

**FOLLOW-ON PROGRAM
REQUIREMENTS**

- Revise the software according to beta-testing results.
- Field the software and begin training (during winter 2000).

POINT OF CONTACT

Mike Eck

PROGRAM PARTNERS

U.S. Army
U.S. Navy
U.S. Air Force
U.S. Marine Corps
Deputy Under Secretary of Defense for Environmental Security

PUBLICATIONS

DoD EPCRA Data Source Evaluation Report. January 1998.

DoD Munitions EPCRA TRI Calculation Methods. December 1998.

Toxic Release Inventory Data Delivery System User's Guide. June 1999.



◆ POLLUTION PREVENTION INVESTMENT FUND

Initiated in 1997 by the Army Office of the Director of Environmental Programs (ODEP), the Pollution Prevention Investment Fund (P2IF) is an important component in the Army's strategy for reducing the overall cost of compliance with legally mandated environmental requirements on Army operations. The Fund emphasizes cost-effective pollution prevention (P2) initiatives that support the Department of Defense Measures of Merit, reduce hazardous or non-hazardous material use and reduce or eliminate environmental requirements at Army installations and facilities.

PURPOSE

The centrally managed and resourced fund provides a mechanism to focus limited resources on high-return P2 investments that lead to permanent source reduction or material process change.

BENEFITS

The P2IF program:

- Provides actual cost-benefit data on P2 processes.
- Evaluates performance of P2 systems.
- Assesses Armywide applicability of P2 technologies.
- Distributes success stories and lessons learned.
- Enhances the opportunity to obtain Other Procurement Army funds for large equipment purchases.
- Funds projects that otherwise may not get funded.
- Saves money.

TECHNOLOGY USERS

All Army activities (including Army Reserve and National Guard).

DESCRIPTION

The P2IF is directed by ODEP and administered by the U.S. Army Environmental Center (USAEC). The fund allows Armywide P2 projects to compete evenly for supplemental P2 resources based on economic payback, waste reduction and toxicity of the major pollutant.

Required performance reports are used to analyze actual cost benefit data and waste reduction data versus project estimates.

ACCOMPLISHMENTS AND RESULTS

Eight projects were funded in fiscal year 1997 for a total of \$325,000, with an estimated annual cost avoidance of \$274,000 and an estimated payback of 1.18 years. Three of these projects were exceptional successes; all exceeded the estimated economic payback. A weapon-cleaning system at Fort Carson reduced weapon-cleaning time by 75 percent and freed up labor hours that had been diverted from other mission activities. A solvent recovery system at Fort Monmouth eliminated methylene chloride from the recovery process and significantly reduced labor hours. Paint bulking and can crushing at Fort Hood reduced the waste stream by approximately 53,000 pounds and eliminated associated storage requirements.

In FY 1999, \$7.5 million (M) was disbursed to 82 projects with an estimated annual cost avoidance of \$6.5M and an estimated payback of 1.14 years.



LIMITATIONS	Availability of funding limits the number of projects. All projects must be consistent with the P2IF Guidance and Procedures.
FOLLOW-ON PROGRAM REQUIREMENTS	<ul style="list-style-type: none">• In FY 2000, the P2IF anticipates funding 77 projects costing \$5.4M with an estimated annual cost avoidance of \$10.1M and an estimated payback of 0.53 years.• For FY 2001 – FY 2005, the fund is programmed for \$10M per year.
PROGRAM PARTNERS	Office of the Director of Environmental Programs All major commands (MACOMs) U.S. Army Environmental Center
POINT OF CONTACT	Bill Nelson
PUBLICATIONS	P2IF guidance and information are provided on the USAEC Web page at http://aec.army.mil/ .

◆ **POLLUTION PREVENTION PLANS REVIEW**

Army installations and major commands must devise detailed plans to prevent pollution. The U.S. Army Environmental Center (USAEC) reviews these plans to ensure their compliance with several Army and federal government requirements.

PURPOSE	To review Army installation and major command (MACOM) pollution prevention (P2) plans.
BENEFITS	Effective P2 plans ensure compliance with Executive Order 12856, Army Regulation 200-1 and guidance from the Assistant Chief of Staff for Installation Management (ACSIM).
TECHNOLOGY USERS	Installation and MACOMs.
DESCRIPTION	ACSIM sent a memo to the MACOMs dated February 11, 1997, detailing ACSIM installation P2 plan elements and listing installation plans not in compliance. A second memo, dated February 10, 1998, required installation P2 plans to attain compliance with ACSIM guidance by June 1998. USAEC continues to monitor compliance.
ACCOMPLISHMENTS AND RESULTS	USAEC staff reviewed plans from the Army MACOMs. Logistics Management, Inc. reviewed installation plans in 1996.
POINT OF CONTACT	Mike Eck



II – HSMS TEAM

◆ HAZARDOUS SUBSTANCE MANAGEMENT SYSTEM

The Hazardous Substance Management System (HSMS) is an integrated program that encompasses two separate but interrelated components: the Hazardous Material Management Program and HSMS software.

PURPOSE

To facilitate centralized hazardous-material control and management and to assist with environmental reporting by tracking hazardous material from the time of request until its departure from an installation.

BENEFITS

Installations using HSMS software while centrally managing and controlling their hazardous materials (HM) have reduced their HM inventories and improved personnel safety. Better business practices have helped many installations reduce hazardous waste (HW) and its associated disposal costs. Most installations that use HSMS software have instituted stringent controls of HM along with shelf-life extension and material reuse programs. These initiatives have saved the Army millions of dollars.

TECHNOLOGY USERS

Department of Defense (DoD) facilities that handle HM and HW, which would require centralized management and an automated tracking system.

DESCRIPTION

The integrated HSMS program encompasses two separate but interrelated components. The first component, the Hazardous Material Management Program (HMMP), assists Army installations in evaluation, selection and implementation of a set of HM management business practices that best meet the needs of their organizations. The HSMS software automatically tracks the hazardous materials and waste that are managed within the context of the HMMP.

In the late 1980s and early 1990s, commanders faced new environmental management and tracking requirements mandated by Executive Order 12856 and the Emergency Planning and Community Right-To-Know Act. They faced strict criminal liabilities under the Resource Conservation and Recovery Act. DoD installations also discovered excessive HM/HW inventories, which led to high waste-disposal costs, unnecessary personnel exposures and a lack of HM visibility and control.

To address these problems, installations began developing nonstandard, *ad hoc* automated tools. DoD had to eliminate redundancy and unnecessary costs stemming from these less-than-optimal business practices and overlapping tracking systems, while enhancing pollution prevention (P2) and environmental compliance.

Army policy letters in 1995 and 1996 directed that HSMS software would be the only authorized Army HM/HW/P2 tracking system. Army activities were to stop developing or buying commercially available software for tracking hazardous substances. As an interim measure, installations operating a system could use that system until HSMS was fully implemented. However, installations were to plan immediately for the transition to HSMS.



Early on, it was recognized that HSMS software alone did not save money or prevent pollution. Only when installations use HSMS software as part of the garrison commander's HMMP are benefits realized.

The management of hazardous materials can be accomplished in many different but equally effective ways. One method is the centralized management that includes a management cell and a supply support activity for receipt, storage and issue. Setting up centralized management/ decentralized storage is another method for managing HM that some Army installations have adopted. Additionally, some installations have implemented several HM management locations throughout their installation.

This mission is not new; HMMP is an established regulatory requirement (Army Regulation 710-2). Centralization of HMMP functions is essential to an effective program and saves Army resources.

The HSMS program is, above all, an installation commander's program. The functional contractors, funded by the U.S. Army Environmental Center (USAEC) and managed by the U.S. Army Corps of Engineers, support the HSMS program by helping installations develop and implement their programs. As an additional resource, Army Headquarters published a Business Practice Guide that provides an overview of HMMP, describes eight potential business-practice initiatives and offers a model organizational approach for HM management.

ACCOMPLISHMENTS AND RESULTS

The Army began fielding the HSMS Program to selected installations in early fiscal year 1996. By the end of FY 1999, 34 sites across the country had achieved initial operational capability. The current installation sequence list – developed by USAEC in consultation with the major Army commands – includes plans to field HSMS at 38 additional installations by the end of FY 2002.

LIMITATION

The Army HSMS program may not be a cost-effective option for smaller installations with non-industrial missions.

FOLLOW-ON PROGRAM REQUIREMENTS

- Complete the HSMS program implementation at all Army installations by the end of FY 2002.

POINTS OF CONTACT

Stan Childs
Charlie George

PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Corps of Engineers
Program Executive Office, Standard Army Management Information Systems,
HSMS Project Office



III – ACQUISITION TEAM

◆ ARMY 500

The Department of Defense requires weapon system program managers to implement hazardous materials management programs and pollution prevention programs. Army 500 is a management tool being developed to help program managers rank hazardous materials and make informed decisions regarding their use.

PURPOSE

To provide an automation tool that helps weapon system program managers (PMs) and staff collect information on hazardous materials and rank the materials based on human toxicity and environmental hazards.

BENEFITS

Army 500 will help program offices analyze hazardous materials and identify opportunities to eliminate the use of these materials. Reducing requirements for hazardous materials will reduce lifecycle costs for weapon systems.

TECHNOLOGY USERS

Program, project and product managers throughout the acquisition community, and environmental staffs at major commands and installations.

DESCRIPTION

Use of hazardous materials increases costs associated with occupational health and safety, as well as environmental liability. Requirements to implement hazardous materials management and pollution prevention programs compel PMs to identify the hazardous materials required in the design, manufacture and support of their weapon systems. Where possible, PMs must eliminate the need for hazardous material use or mitigate the environmental, health and safety impacts when elimination is impossible. Army 500 is designed to assist in the evaluation of hazardous materials for elimination.

Army 500 consists of an Excel spreadsheet, into which PM staffs can enter information on known hazardous materials and their applications. Once the data is entered for all materials under consideration, the spreadsheet ranks the materials according to human toxicity and environmental hazard. Inputs to the spreadsheet include factors for permissible exposure limits, threshold limit values, reportable quantities, legislative risk, and treatment and disposal methods. The spreadsheet also considers costs and produces a rank-ordered listing with values assigned for each factor. The spreadsheet will be made available to the acquisition community and other potential users on a World Wide Web site.

ACCOMPLISHMENTS AND RESULTS

Army 500 is near completion. The spreadsheet has been designed and is being revised to make it easier to use. A user's guide has been developed. To demonstrate Army 500 and its capabilities, the U.S. Army Environmental Center has developed a sample spreadsheet using hazardous materials supplied by the Comanche program.

POINTS OF CONTACT

James Heffinger
Dean Hutchins



PROGRAM PARTNERS

U.S. Army Environmental Center
PM-Comanche



COMANCHE HELICOPTER PROGRAM ENVIRONMENTAL LIFECYCLE COST ESTIMATE

The Department of Defense (DoD) requires weapon system program managers (PMs) to integrate environmental considerations into their acquisition strategies and include environmental costs in their program cost estimates. The U.S. Army Environmental Center (USAEC) has been asked to assist the Comanche program office and the U.S. Army Cost and Economic Analysis Center (CEAC) in the development of lifecycle environmental costs for the Comanche helicopter system.

PURPOSE

To develop and verify the environmental lifecycle costs for the Comanche helicopter system.

BENEFITS

By identifying program environmental cost elements, weapon system PMs can make informed decisions on environmental issues by evaluating their impacts on long-term costs. Identification of environmental costs helps the Army develop more accurate and complete lifecycle cost estimates for weapon system acquisition programs.

TECHNOLOGY USERS

Program Executive Officer (PEO)-Aviation, PM-Comanche and the U.S. Army CEAC.

DESCRIPTION

In a 1997 audit, the DoD Inspector General found that environmental costs were not fully included in the Comanche program's cost estimates. In fact, the Inspector General found the Comanche cost estimate might be understated. As a result of the audit, PM-Comanche and CEAC requested USAEC assistance in identifying and estimating lifecycle environmental costs.

This project required analysis of the entire acquisition plan for the Comanche helicopter program, identification of all activities with environmental impacts, and estimation of all associated environmental costs. Costs were correlated to a work-breakdown structure for the program and documented using CEAC-approved cost-documentation formats.

Lessons learned from this and other projects will be included in an environmental cost handbook. The handbook will serve as a guide for PEOs and PMs to estimate their programs' environmental lifecycle costs.

ACCOMPLISHMENTS AND RESULTS

USAEC has completed this estimate and is working with PM Comanche and CEAC to provide support for a Milestone II Review and decision in March 2000. Face-to-face coordination with program office representatives, depot representatives and system users helped USAEC identify all environmental activities and impacts.



PM-Comanche used the interim results of this project in fiscal year 1998 to respond to the DoD Inspector General.

POINT OF CONTACT

James Heffinger

PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Cost and Economic Analysis Center
PM-Comanche
Fort Campbell, Kentucky
Corpus Christi Army Depot, Texas



ENVIRONMENTAL COST HANDBOOK

The Department of Defense (DoD) requires program executive officers (PEOs) and program managers (PMs) to integrate environmental considerations into their acquisition strategies and include environmental costs in their lifecycle cost estimates. Environmental lifecycle costing is a relatively new requirement, and little guidance is available to assist PEOs and program managers. The *Environmental Cost Handbook* will describe how to identify and estimate lifecycle environmental costs for weapon systems.

PURPOSE

To develop a handbook that describes how to identify and estimate lifecycle environmental costs for weapon systems.

BENEFITS

Recognition of environmental costs will allow PEOs and PMs to evaluate impacts on lifecycle costs and make informed decisions on environmental issues.

TECHNOLOGY USERS

PEOs, PMs, other acquisition officials and the U.S. Army Cost and Economic Analysis Center (CEAC).

DESCRIPTION

The U.S. Army Environmental Center (USAEC) is supporting the CEAC Weapon System Cost and Economic Analysis Division in developing and verifying environmental lifecycle costs for Army weapon systems. This support has required close coordination with several weapon system program offices. USAEC confirmed there is no "how to" guidance available for identification and estimation of environmental costs.

The *Environmental Cost Handbook* is being developed to help PEOs and PMs figure environmental costs as independent values. The handbook will provide guidance in a way that allows PEOs and PMs to associate estimated costs with work-breakdown structure elements to support activity-based costing and performance monitoring.

The handbook will offer approaches for developing categories of environmental costs. For each environmental category or activity, potential sources of existing cost information will be identified along with guidance for



developing cost-estimating relationships. The goal is to provide guidance flexible enough to support the estimation of environmental lifecycle costs for most weapon systems.

ACCOMPLISHMENTS AND RESULTS

USAEC is nearing completion of two environmental lifecycle cost estimates (Comanche and Apache helicopter programs). Lessons learned, cost formulas, sources for environmental cost information and other elements are being documented for potential use in the handbook. Lifecycle cost estimating is about to begin for two other weapon systems; the results from these estimates will also be used in developing the handbook.

POINT OF CONTACT

James Heffinger

PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Cost and Economic Analysis Center
PM-Comanche
PM-Apache



LONGBOW APACHE COST ANALYSIS WORKING-LEVEL INTEGRATED PRODUCT TEAM SUPPORT

Weapon system program managers must integrate environmental considerations into their acquisition strategies and include environmental costs in their program lifecycle cost estimates. The Weapon System Cost and Economic Analysis Division of the U.S. Army Cost and Economic Analysis Center requested U.S. Army Environmental Center (USAEC) support in the development of environmental lifecycle cost estimates for the Longbow Apache upgrade program.

PURPOSE

To develop an environmental lifecycle cost estimate for inclusion in the Army cost position for the Longbow Apache system.

BENEFITS

Department of Defense regulations (DoD 5000.2-R) require program managers (PMs) to identify the lifecycle costs for their systems, including environmental costs. This project will help the PM for the Apache helicopter comply with this acquisition requirement. Identification of environmental costs will also help the PM make informed decisions on environmental issues by allowing him to evaluate the long-term costs of alternative courses of action.

TECHNOLOGY USERS

PM-Apache, the U.S. Army Cost and Economic Analysis Center (CEAC), and the Longbow Apache Cost Analysis Working-Level Integrated Product Team (CA-WIPT).

DESCRIPTION

A portion of the A-model Apache fleet will be modified to the Longbow configuration. The new configuration includes mast-mounted fire control



radar, a modified airframe and a radio frequency autonomous seeker in an upgraded HELLFIRE missile system. The PM must develop a program office estimate, which includes all lifecycle costs for the upgrade program. CEAC will develop an independent cost estimate to evaluate the accuracy of the program estimate. Differences in the two estimates will be arbitrated to produce a final recommended Army cost position. USAEC will participate in this process by developing a lifecycle estimate for environmental costs. Both the PM and CEAC will use USAEC's environmental cost estimate.

USAEC will evaluate all phases of the acquisition strategy and identify activities with environmental impacts. Costs will be attached to environmental impacts and requirements; the total of all environmental costs will become the lifecycle environmental estimate. USAEC will coordinate closely with representatives from the program office, manufacturers and system users to identify all environmental activities. Costs will be documented using a work-breakdown structure developed specifically for the Longbow Apache program. Cost descriptions and methodologies will be documented using CEAC-approved cost-documentation formats.

Lessons learned from this and other projects will be used to develop an environmental handbook, which CEAC and the acquisition community can use to estimate environmental costs. The handbook will include descriptions of environmental cost elements, cost estimating methodologies, and recommended sources of cost information.

ACCOMPLISHMENTS AND RESULTS

- On September 22, 1998, USAEC participated in the first meeting for the CA-WIPT.
- On November 16, 1998, USAEC staff attended an in-process review, during which the program staff discussed its planned methodologies for developing a program cost estimate.
- In January 1999, USAEC staff visited the program office at Redstone Arsenal, Alabama, to create plans and schedules for developing the environmental cost estimates.
- On April 22, 1999, a meeting was held to initiate and facilitate data collection for the Apache model D ELCC. The Cost Analysis Requirements Description, Program Office Estimate (POE), and fielding schedule for both the helicopter and the simulator were obtained. Additionally, representative military sites for data collection were established.
- USAEC representatives have been attending Cost Review Board meetings since May 1999 to ensure environmental lifecycle costs are being identified and accounted for.
- Data collection visits (to capture Apache Model D ELCC) have been made to the Utah National Guard, Fort Hood (the location for all Apache training and the site of the only currently deployed AH-64D battalion), the prime vendor/contractor (located in Mesa, Arizona), and the Corpus Christi Army Depot.



FOLLOW-ON PROGRAM REQUIREMENTS

- Data collection visits will be made to Fort Campbell (home of the next AH-64D battalion to be fielded) and Fort Bragg (home of two Apache battalions and the red cockaded woodpecker – a threatened and endangered species with impact on Army weapon systems).
- A Data collection will take place at Fort Irwin (National Training Center)/Fort Polk (Joint Readiness Training Center). This will be an excellent source of environmental data because units, as they deploy from their home station, must pay for every aspect of deployment including environmental impact and cleanup.
- A final data collection visit will be made to U.S. Army, Europe, where host nation stationing involves special environmental laws and requirements from certification to disposal. Environmental costs are particularly high in Germany.
- Publish Apache model D ELCC estimate final report.

POINT OF CONTACT

Louis Kanaras

PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Cost and Economic Analysis Center
PM-Apache

**NEPA MANUAL FOR MATERIEL ACQUISITION**

Recent government audits of selected Defense Department acquisition programs revealed that compliance with the National Environmental Policy Act (NEPA) had not been properly factored into the acquisition management process. This manual will provide information to help program managers (PMs) consider NEPA during materiel acquisition.

PURPOSE

To provide advisory information for integrating the requirements of NEPA and Army Regulation (AR) 200-2, *Environmental Analysis of Army Actions*, into the materiel acquisition process.

BENEFITS

This manual will simplify the NEPA process so PMs understand when to use a Categorical Exclusion (CX) or Record of Environmental Consideration (REC), an Environmental Assessment (EA) or Environmental Impact Statement (EIS), and feel comfortable with each approach.

TECHNOLOGY USERS

Department of Defense (DoD) PMs and program executive officers (PEOs).

DESCRIPTION

NEPA requires the identification and analysis of potential environmental impacts of certain federal actions and alternatives before those actions can be initiated. The law also contains specific requirements for informing and involving other federal and state agencies and the public. NEPA requires a systematic, interdisciplinary approach to analyzing and considering environmental factors when planning or conducting federal agency programs and projects. The process for implementing the law is codified in Council on



Environmental Quality Regulations, 40 Code of Federal Regulations (CFR) Parts 1500-1508.

Recent government audits revealed that NEPA compliance had not been properly factored into several DoD acquisition programs. This was likely due, in part, to the false assumption that NEPA is primarily of concern only to installation and facility engineers.

This manual will provide information for integrating the requirements of NEPA and AR 200-2 into the materiel acquisition process. The information will assist PEOs and PMs with the implementation of NEPA policies and procedures as they pertain to Army materiel acquisition. The manual is being developed as a "living" document, compiled in a loose-leaf format for convenient updating.

There is a significant effort within DoD to reduce the number of mandatory policies, procedures and practices for the acquisition of weapon systems and other Army materiel. This manual will offer PEOs and PMs flexibility in satisfying the goals of NEPA.

ACCOMPLISHMENTS AND RESULTS

The coordinating draft of the *NEPA Manual for Materiel Acquisition* has been completed.

FOLLOW-ON PROGRAM REQUIREMENTS

- Staff updated the *NEPA Manual* by transmittal letter from Assistant Secretary of the Army (ASA) for Installations and Environment to ASA for Acquisition, Logistics and Technology to send out to PEO/Department of the Army (DA) staff/field activities for final comment.
- Incorporate final comments into the *NEPA Manual for Materiel Acquisition*.
- Distribute final *NEPA Manual for Materiel Acquisition* to acquisition community.

POINT OF CONTACT

Louis Kanaras

PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Space and Missile Defense Command
Teledyne Brown Engineering

◆ PROGRAMMATIC ENVIRONMENTAL, SAFETY AND HEALTH EVALUATION GUIDE

Department of Defense (DoD) Regulation 5000.2-R requires that all programs, regardless of acquisition category, include a programmatic environmental, safety and health (ESH) evaluation in their acquisition strategy. The regulation does not set a format for this evaluation but requires it to describe a program manager's (PM's) strategy for meeting ESH requirements, establishing responsibilities and tracking progress. Developing a guide for such evaluations will help PM's plan, execute and document actions that fulfill the ESH requirements of DoD 5000.2R.



PURPOSE	To develop a guide for analyzing five specific environmental, safety and health areas: National Environmental Policy Act, Environmental Compliance, System Safety and Health, Hazardous Materials and Pollution Prevention.
BENEFITS	The development of an ESH evaluation helps ensure those actions that fulfill the environmental, safety and health requirements of DoD Regulation 5000.2-R are planned, executed and documented.
TECHNOLOGY USERS	DoD PMs and program executive officers.
DESCRIPTION	<p>DoD 5000.2-R requires that all programs, regardless of acquisition category, include a programmatic ESH evaluation in their acquisition strategy. The PM must initiate the ESH evaluation at the earliest possible time in support of a program initiation decision (usually Milestone I) and update the evaluation throughout the program's lifecycle.</p> <p>The <i>Programmatic Environmental, Safety and Health Evaluation Guide</i> will help PMs meet these requirements by providing an approach for developing a comprehensive ESH evaluation. The approach will help ensure the development of an ESH evaluation that meets DoD requirements, and will make sure potential program "showstoppers" are identified and resolved early in the acquisition process. The evaluation will document the program's ESH status, establish a process for monitoring changing compliance requirements, integrate ESH requirements into the program's acquisition strategy and other documentation, and establish a plan to meet future ESH requirements.</p>
ACCOMPLISHMENTS AND RESULTS	<ul style="list-style-type: none">● Received and incorporated comments on the draft ESH guide.● Developed the coordinating draft of the ESH guide and distributed for comments.● Obtained program executive officer (PEO) comments.● Developed updated ESH guide (July 1999) based upon PEO comments.
FOLLOW-ON PROGRAM REQUIREMENTS	<ul style="list-style-type: none">● Staff updated ESH guide by transmittal letter from Assistant Secretary of the Army (ASA) for Installations and Environment to ASA for Acquisition, Logistics and Technology to send out to PEO/ Department of the Army (DA) staff field activities for final review.● Obtain consensus of PEO/DA staff/field activities.● Produce final ESH guide (incorporating all comments).● Distribute final ESH guide.
POINT OF CONTACT	Louis Kanaras
PROGRAM PARTNERS	U.S. Army Environmental Center U.S. Army Space and Missile Defense Command Teledyne Brown Engineering



*ENVIRONMENTAL
TECHNOLOGY
PROGRAMS*



P2&ETD technology development and transfer programs enable the Army to test and implement cost-effective technologies in cleanup, compliance, pollution prevention and conservation.

CLEANUP

Many Army sites hold remnants from past training, testing and industrial operations. P2&ETD supports Army efforts to clean up these areas by providing cost-effective technologies to remove pollutants from soil, surface water and groundwater.

COMPLIANCE

Army installations must comply with laws and regulations governing wastewater discharge, noise abatement, air quality, and management of solid and hazardous waste. P2&ETD initiatives help the Army stay ready to meet constant changes in environmental laws.

POLLUTION PREVENTION

P2&ETD demonstrates and transfers cost-effective industrial process changes and technologies designed to help installations prevent pollution, use fewer hazardous materials and generate less hazardous waste.

CONSERVATION

The Army manages 12 million public acres, which include a variety of natural and cultural resources. P2&ETD supports Army efforts to protect these irreplaceable resources while providing realistic backdrops for military training.



◆ BIOVENTING OF POL-CONTAMINATED SOILS

Many operational facilities contain soil contaminated with petroleum, oils and lubricants (POLs). Excavation of this soil for remediation can disrupt Army operations. Bioventing offers an alternative to excavation and incineration by relying on existing microorganisms to remediate the waste.

PURPOSE

To transfer bioventing technology from the Air Force for use in remediating POL-contaminated sites on Army installations.

TECHNOLOGY USERS

Army installations.

DESCRIPTION

Many Army sites contain POL contamination. These sites include aircraft areas, maintenance areas, leaking storage tanks, burn pits, chemical disposal areas, disposal wells and leach fields, landfills and burial pits, fire-fighting training areas and surface impoundments.

POL contamination in the unsaturated (vadose) zone exists in four phases: vapor in the pore spaces; sorbed to subsurface solids; dissolved in water; or as non-aqueous phase liquid (NAPL). The nature and extent of transport are determined by the interaction among contaminant transport properties (e.g., density, vapor pressure, viscosity and hydrophobicity) and the subsurface environment (e.g., geology, aquifer mineralogy and groundwater hydrology).

Common treatment technologies for POLs in soil include excavation and landfilling, biodegradation, incineration, soil vapor extraction (SVE) and low-temperature thermal desorption. Implementing in-situ remediation techniques would greatly reduce cleanup costs for POL-contaminated sites.

The Air Force Center for Environmental Excellence (AFCEE) developed bioventing, which is the process of providing naturally occurring soil microorganisms with oxygen to promote in-situ degradation of POLs. The basic elements of a bioventing system include a well – or series of wells – and a blower system that pumps air through the well and into the ground.

This technology transfer effort consists of treatability studies and full-scale demonstrations at various sites. Testing bioventing under real scenarios will build confidence in the technology and increase awareness among Army users.

Based on AFCEE and commercial applications, costs for operating a bioventing system range from \$10 to \$60 per cubic yard. The time required to clean up a site ranges from one to five years to remove benzene, toluene, ethylbenzene and xylene (BTEX) constituents and two to 10 years to remove total petroleum hydrocarbons (TPH). Many factors, including contaminant type and concentration, soil permeability, spacing and number of wells, pumping rate and off-gas treatment, can affect cost and duration. For these reasons, initial treatability studies must be performed to determine bioventing's effectiveness at each site.



Bioventing does not require expensive equipment, and systems can be left unattended for long periods. Typically, only periodic maintenance and monitoring are conducted.

ACCOMPLISHMENTS AND RESULTS

- In May 1997, the pilot system at Fort Carson, Colorado, was scaled up to provide full-scale remediation. Yearly testing in May 1998 indicated that contaminant levels had been reduced below state action levels. Consent is being sought from the state to close the site.
- The pilot system at Fort Rucker, Alabama, provided full-scale cleanup. Testing in September 1998 found that BTEX compounds had been reduced to nondetectable levels, and TPH had been greatly reduced in the treatment area. Documentation was submitted to the state to support site closure.

LIMITATION

In May 1997, annual testing of the pilot system at Fort Bliss, Texas, indicated that biological activity had decreased while contaminant levels remained elevated. This phenomenon has occurred at several of the Southwestern desert sites where bioventing systems have operated for extended periods. The decrease in biological activity may be due to a variety of factors, such as low soil moisture or lack of nutrients.

FOLLOW-ON PROGRAM REQUIREMENT

Document the study results on the U.S. Army Environmental Center (USAEC) Web site and in various publications to promote the use of bioventing within the Army.

POINT OF CONTACT

Gene Fabian

PROGRAM PARTNERS

U.S. Army Environmental Center
Fort Bliss, Texas
Fort Rucker, Alabama
Fort Carson, Colorado



C-SPARGE TREATMENT SYSTEM AT LETTERKENNY ARMY DEPOT

The C-Sparge treatment system promises to be an effective way to remove volatile compounds from water. Installation of this system at the Rowe Spring site at Letterkenny Army Depot, Pennsylvania, will help remove contamination and treat a water supply for livestock.

PURPOSE

To prepare and implement a final design of the C-Sparge treatment system for the Rowe Spring site at Letterkenny Army Depot, an installation on the National Priorities List.

BENEFITS

If installed successfully, this system will help remove volatile organic compound (VOC) contamination, protect the surrounding environment and provide a treated water supply for livestock.



TECHNOLOGY USERS	Letterkenny Army Depot
DESCRIPTION	The U.S. Army Environmental Center (USAEC) awarded a contract to conduct bench-scale and pilot tests of the system, complete the design and construct the treatment system. Effluent testing will begin after system construction. A basic C-Sparge treatment system uses a fine-bubble diffuser to facilitate the removal of contaminants from the affected media.
ACCOMPLISHMENTS AND RESULTS	USAEC awarded a contract for design and installation of the Rowe Spring treatment system. The bench test results showed the technology was effective in reducing VOC concentrations.
FOLLOW-ON PROGRAM REQUIREMENTS	<ul style="list-style-type: none">• Conduct C-Sparge system pilot test.• Issue draft version of the final design.• Complete system construction.• Start treatment system and initiate effluent testing.
POINT OF CONTACT	Scott Hill



EVALUATING NATURAL ATTENUATION AT INDUSTRIAL OPERATIONS COMMAND SITES

Numerous Army Industrial Operations Command (IOC) installations contain sites where past production, testing and training activities left contamination in the soil and groundwater. In this project, natural attenuation will be evaluated as a potential cleanup remedy at IOC sites contaminated with petroleum hydrocarbons, solvents or metals.

PURPOSE	To evaluate the feasibility of implementing natural attenuation as a potential cleanup remedy at sites contaminated with petroleum hydrocarbons, solvents or metals.
BENEFITS	Contaminated sites across IOC will be evaluated for application of natural attenuation using a standard methodology. This will enhance the success of employing natural attenuation as an alternative to more costly, engineered remediation options.
TECHNOLOGY USERS	Department of Defense (DoD) installations.
DESCRIPTION	A standardized methodology was developed to consider the feasibility of applying natural attenuation as a cleanup option, and provide decision-makers with a quantitative “bottom line” to judge the success of employing natural attenuation.



A query of the Army's Defense Site Environmental Restoration Tracking System (DSERTS) database identified more than 200 IOC sites with petroleum, solvent or metals contamination. This list was trimmed to 99 sites by eliminating those that indicated contamination mixed with inorganics, explosives, pesticides or herbicides. Cleanup priority and cost information gathered from Installation Action Plans and the policies of state regulatory agencies on natural attenuation were then used to narrow the list to the top 20 sites.

The next step involved gathering data on the extent and magnitude of contamination; the geologic and hydrogeologic formation; the location of the contamination sources; and the distances to potential receptors for each of these 20 sites. This information was used to compare the rate of contaminant transport to the rate of physical and biological attenuation using BIOSCREEN, an analytical solute transport model developed by the Air Force Center for Environmental Excellence (AFCEE). The study then described the top sites in order of priority, and identified gaps in data required to complete full-scale natural attenuation modeling.

Finally, the cost of pursuing natural attenuation for the top 10 of these sites was evaluated. This included the cost of gathering the data necessary to conduct comprehensive natural attenuation transport modeling, and the expense of site monitoring for up to 30 years. A final matrix was prepared to present the benefits and drawbacks of the selected sites, provide additional data for completing full-scale risk-based natural attenuation modeling, and compare the cost of natural attenuation to engineered remediation.

POINT OF CONTACT

Mark Hampton

PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Industrial Operations Command
U.S. Army Tank-automotive and Armaments Command
Platinum International, Inc.

PUBLICATIONS

A report will be available at the conclusion of the project (first quarter, FY 2000).

Evaluation of Natural Attenuation at Industrial Operations Command Site.
Oct. 99. SFIM-AEC-ET-CR-99042.

◆ **ENHANCED BIOREMEDIATION AT INDUSTRIAL OPERATIONS
COMMAND SITES**

Numerous Army Industrial Operations Command (IOC) installations contain sites where past production, testing and training activities left contamination in the soil and groundwater. In this project, 15 solvent-contaminated sites that showed suboptimal potential for groundwater remediation by natural attenuation



were analyzed for their potential for enhanced bioremediation.

PURPOSE	To evaluate the feasibility of boosting intrinsic bioremediation as a potential cleanup remedy at sites contaminated with petroleum hydrocarbons or solvents.
BENEFITS	The study indicates that in-situ enhancement of intrinsic bioremediation may be an effective alternative to more costly engineered cleanups at several IOC installations.
TECHNOLOGY USERS	Department of Defense (DoD) installations.
DESCRIPTION	<p>Fifteen IOC sites with petroleum, oil and lubricants (POLs), or solvent contamination in the groundwater that showed suboptimal potential for remediation by natural attenuation were selected to assess their potential for enhanced bioremediation. The natural attenuation screening was done using BIOSCREEN, an analytical solute transport model developed by the Air Force Center for Environmental Excellence (AFCEE) that compares the rate of contaminant transport to the rate of contaminant attenuation at a given site. Field-scale case studies and laboratory studies where enhanced bioremediation was performed were reviewed to identify methods of enhancement and the increase in biodegradation rate due to the enhancement.</p> <p>The 15 sites were then analyzed with respect to the potential for enhanced bioremediation and ranked in order of priority. The method of bioremediation enhancement depends on the electron acceptor/reduction/oxidation (Redox) condition in the groundwater at the site. Unfortunately, this was not measured at the candidate sites. As a result, several options that represent electron acceptor and Redox conditions that may exist at a site are provided. The proposed enhanced bioremediation treatment, the treatment delivery system, and the enhanced degradation half-lives for the contaminants of concern for each of the options presented are described. For each candidate site, a comparison of the enhanced biodegradation half-life necessary and the degradation half-life obtainable was made. The analysis demonstrated that enhanced bioremediation can be successful at all sites.</p>
POINT OF CONTACT	Mark Hampton
PROGRAM PARTNERS	U.S. Army Environmental Center U.S. Army Industrial Operations Command Platinum International, Inc.
PUBLICATIONS	<i>Enhanced Bioremediation at Industrial Operations Command Sites</i> . USAEC Report SFIM-AEC-ET-CR-99063. August 1999.



◆ FIELD ANALYTICAL TECHNOLOGY

The major source of error associated with an analytical result is derived from sampling, yet little has been done to improve the process. A cost-effective method to accurately determine the distribution of contaminants will benefit Army site-remediation efforts.

PURPOSE

To create a procedure whereby the error associated with collecting soil samples can be applied correctly to the analytical results; to develop a strategy and procedure to determine explosives contamination at impact ranges; and adapt the procedure to other analytes when appropriate.

BENEFITS

A cost-effective method to determine the distribution of contaminants will benefit the site-remediation process. Because they contain unexploded ordnance (UXO), impact ranges present a unique cleanup challenge. Some Records of Decision require the Army to deal with explosives before addressing UXO. The developed strategy will allow installations to handle this scenario.

TECHNOLOGY USERS

Army installations with explosives-contaminated soils.

DESCRIPTION

The major source of error associated with an analytical result is derived from sampling, but little has been accomplished to improve the process. Previous sampling was based on a specified grid approach, which resulted in extreme sampling error for nonhomogenous distributed contaminants such as explosives. True and cost-effective determination of the distribution of contaminants is essential to the site remediation process.

A site contaminated with cyclotetramethylene (HMX) and trinitrotoene (TNT) will be assessed. A final report will document the sampling and analytical errors associated with short-range and longer-range analyte distributions for this site. The report also will document improvements in site characterization that result from the use of a composite-based sampling procedure and onsite analysis, and address whether this approach reduced sampling error to acceptable levels for this site.

Additional sampling and analysis studies will be conducted to demonstrate the effectiveness of the combination of onsite analytical methods and simple composite sampling procedures. Sites contaminated with Royal Demolition Explosive (RDX) and nitroguanidine (NG) will be sampled (if available), as well as a non-explosives-contaminated site, to assess whether levels of heterogeneity at these sites are similar to those observed for sites contaminated with TNT, dinitrotoene (DNT), ammonium picrate and HMX. An evaluation will be performed between field analytical results and laboratory analytical results.

ACCOMPLISHMENTS AND RESULTS

In Phase 1 of this project, several explosives-contaminated sites were intensely sampled to obtain information on the short-range heterogeneity of analyte distribution as a function of the specific contaminant, mode of contamination and soil type. The samples were analyzed both on and off site.



These results were used to compute overall analytical error. The onsite analytical methods for TNT, DNT and picric acid provided adequate data for site assessment at much lower costs. Based on these results, various strategies to minimize sampling error were considered, and a larger-scale sampling strategy proposed.

This approach was evaluated in Phase 2 at a site contaminated with HMX and TNT. Analysis of larger-scale sampling and analytical results indicated that an approach based on discrete grab sample collection and analysis could not adequately describe analyte concentrations. A rapid compositing approach was assessed, and the analysis of these results showed this was the best approach for sampling nonhomogenous distributed contamination. This approach was further validated at a site contaminated with RDX and TNT. It also underwent preliminary testing at an impact range.

In the next phase, a pilot study on applying the sampling strategy learned from the previous effort was performed at an inland impact range at Fort Ord, California. Because of the UXO issue, the strategy was modified to include actual sampling being performed by Explosive Ordnance Disposal (EOD) personnel. Sampling was also modified to address the effects of long-range heterogeneity. Experiments were conducted to assess the utility of a Gas Chromatograph-Nitrogen/Phosphorous Detector method for onsite analysis of explosives in soil. Results were promising in that they allowed measurement of RDX in the presence of large amounts of HMX, a contaminant situation often encountered at anti-tank firing ranges.

The Field Analysis using the gas chromatograph (GC) was further tested with both a Nitrogen/Phosphorus detector and an Electron Capture detector. Various archived samples were checked by the gas chromatographic technique, with good results when compared to standard explosives analyses. To field test the technology, participation was sought and received from the Environmental Protection Agency for their Environmental Technology Program for the Evaluation of Explosive Field Analytical Techniques at the Oak Ridge National Laboratory. A new version of the GC was tested at this time. The chromatograph was configured so that air could be used as the carrier gas, which allowed for extreme portability of the system. At the same time, a thermionic ionization detector, a new detector more sensitive to explosives, was tested. Preliminary results show very good correlation for the TNT analyses. However, some breakdown in the RDX analysis occurs when using air as the carrier gas. A different gas/injector system will have to be tested to bring the use of this technology to its maximum potential.

FOLLOW-ON PROGRAM REQUIREMENTS

A strategy based on the previous experiences will be developed to sample impact ranges and perform appropriate analyses. Site(s) will be selected to demonstrate the strategy. The strategy will be revised, when necessary, based on earlier demonstrations. Revised procedures will be demonstrated at additional sites to factor in differences between sites and contaminants. Ruggedness and universality of the application will be demonstrated. Procedures will be developed to guide the application to the "different" site. Results will be provided in final reports.



POINT OF CONTACT

Martin Stutz

PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Engineer Research and Development Center-Cold Regions
Research and Engineering Laboratory

PUBLICATIONS

Assessment of Sampling Error Associated with Collection and Analysis of Soil Samples at Explosives-Contaminated Sites. CRREL Special Report 96-15.

EPA ORD/OSWER. *Field Sampling and Selecting On-Site Analytical Methods for Explosives in Soil – EPA Federal Facilities Forum Issue.* Report EPA/540/R97/501. November 1996.

Assessment of Sampling Error Associated with Collection and Analysis of Soil Samples at a Firing Range Contaminated with HMX. CRREL Special Report 97-22.

Site Characterization of the Inland Firing Range Impact Area at Fort Ord. CRREL Special Report 98-9.

Determination of Nitroaromatic, Nitramine, and Nitrate Ester Explosives in Water Using Solid-Phase Extraction and GC-ECD: Comparison With HPLC. CRREL Special Report 98-2.

Determination of Nitroaromatic, Nitramine, and Nitrate Ester Explosives in Soils by Gas Chromatography-Electron Capture Detection. CRREL Special Report 99-12.

On-Site Method for Nitroaromatic and Nitramine Explosives in Soil and Groundwater Using GC-NPD. CRREL Special Report (In Press).



FIELDING BIOTREATMENT TECHNOLOGIES UNDER THE AGRICULTURE-BASED BIOREMEDIATION PROGRAM

The Agriculture-Based Bioremediation Program (ABRP) is a Congressionally sponsored partnership between the Army and the U.S. Department of Agriculture to demonstrate agronomic remediation processes to restore contaminated military and civilian sites – with emphasis on sites in the Pacific region.

PURPOSE

To demonstrate agronomic remediation processes to restore contaminated military and civilian sites, emphasizing sites in fragile Pacific island ecosystems.

BENEFITS

Besides proving out dual-use agriculturally based technologies, the program actively supports capability building and education, and provides economic opportunities and environmental security to island communities.



TECHNOLOGY USERS

Department of Defense (DoD) installations.

DESCRIPTION

A variety of field demonstrations is being conducted under the ABRP.

Green waste composting was demonstrated in 1998 at Schofield Barracks, Hawaii. This project evaluated the performance and cost of alternative composting methods for reducing green waste to useful horticulture products. Both aerated static pile and commercial in-vessel aerated static pile processes produced quality, finished compost in 55 days. The Army's cost/benefit analysis anticipates the economic return on green waste composting will pay for the process within two years of operation, while reducing the installation's nonhazardous waste stream.

The U.S. Army Corps of Engineers is performing pilot-scale tests of multiple methods of composting green waste and sewage sludge from the Schofield Barracks wastewater treatment plant. The performance and cost of aerated static pile and windrow composting will be compared to a commercial in-vessel aerated static pile process. The potential cost avoidance is significant, since Schofield Barracks alone pays \$10,000 a month to dispose of its sewage sludge and about \$130,000 a month in tipping fees for green-waste disposal.

Del Monte Fresh Produce, Inc. is conducting a field demonstration of phytoremediation to treat groundwater contaminated with volatile organic compounds (VOCs), including ethylene dibromide, 1,2 dibromo-3-chloropropane and 1,2 dichloropropane. Pilot-scale tests have shown the *Luecaena leucophala* (or Koa Haole) plant can effectively remove the contaminants for half the cost of carbon treatment. After test results permit authorities to assess the long-term effectiveness of the process, the phytotreatment units can be scaled up to remediate a site on the Environmental Protection Agency's National Priorities List.

The Dole Food Company, in partnership with the Navy in Hawaii, will field-test a 1.3-acre phytotreatment wetland to biotreat municipal wastewater for use in aboveground irrigation. Recovery of wastewater has important commercial and municipal applications across the islands, where fresh water can be scarce.

RESULTS AND ACCOMPLISHMENTS

A Broad Agency Announcement (BAA) was initiated in October 1998 to open the program to more government, commercial and academic participants. The BAA is available at www.mvk.usace.army.mil/contract (select "Procurement Opportunities," then "Broad Agency Announcements").

The ABRP has initiated several new projects through its BAA. The program conducts additional field demonstrations ongoing in the following areas:

- Bioremediation of slaughterhouse wastewater using the "Living Machines" process
- Bioremediation of petroleum, oil, and lubricant (POL)-contaminated soils



- Phytotreatment of contaminated sediments using manufactured soils
- Phytoremediation of explosives-contaminated soils

The University of Hawaii has added summaries of ABRP projects under its Bioremediation Web site, at <http://www.hawaii.edu/abrp/>.

FOLLOW-ON PROGRAM REQUIREMENTS

- Monitor the progress of ongoing ABRP demonstrations.
- Facilitate technology transfer.

POINT OF CONTACT

Mark Hampton

PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Department of Agriculture
U.S. Army Engineer Research and Development Center-Waterways Experiment Station
Tennessee Valley Authority

PUBLICATIONS

U.S. Army, *Pacific Pilot Compost Facility, U.S. Army Garrison, Hawaii, Schofield Barracks, Final Report*. May 1998.

Biosolids and Green Waste Composting. Schofield Barracks and Wheeler Army Airfield. Nov. 1999.

Other reports will become available as individual projects are completed.



GROUNDWATER EXTRACTION AND TREATMENT EFFECTIVENESS REVIEWS

The U.S. Army spends millions of dollars each year to operate and maintain major groundwater pump-and-treat systems, but most of the systems have no defined measures of effectiveness. The Groundwater Extraction and Treatment Effectiveness Reviews (GWETER) will help installations determine how well a system is performing, when the system has reached the end of its usefulness, or whether another method could meet remediation goals at lower costs.

PURPOSE

To institute an Armywide program for developing clear remediation objectives and measures of effectiveness for planned and installed groundwater pump-and-treat systems. For systems where remedial objectives cannot yet be obtained, the program will reevaluate and renegotiate the objectives using risk-based approaches and reasonable land-use scenarios.

BENEFITS

Optimization of existing systems and the proper setting of objectives could help the Army avoid costs of \$100 million in the next 10 years.



TECHNOLOGY USERS

Major Army commands and installations with operating or proposed pump-and-treat systems.

DESCRIPTION

The U.S. Army operates major groundwater pump-and-treat systems at 35 installations, with a yearly operations and maintenance cost of approximately \$25 million. Each major system costs about \$3 million to build and is expected to last at least 30 years. Of the systems with a definable objective, more than half were designed to contain plumes, not restore aquifers. Most of the systems have no defined measures of effectiveness; the Army therefore has little or no ability to determine how well a system is performing or when a system has reached the end of its usefulness. In addition, approximately 70 major pump-and-treat systems are in the planning stages within the Installation Restoration, Base Realignment and Closure (BRAC) and Formerly Used Defense Sites (FUDS) programs.

An Army Science Board study on the effectiveness of groundwater and soil treatments recommended that a team of independent experts review the Army's largest groundwater pump-and-treat remediation programs (according to cost-to-complete estimates). The study also recommended implementing a groundwater cleanup strategy to reduce the number of pump-and-treat systems being proposed in the Army's environmental program.

The Groundwater Extraction and Treatment Effectiveness Reviews (GWETER) will:

- Validate the objectives of remediation systems;
- Determine measures of effectiveness;
- Collect the data necessary to measure system effectiveness;
- Examine the remediation objectives and compare these goals to appropriate human and ecological risk levels for the current and future site use;
- Create a process for acquiring the resources to implement system modification and/or replacement where significant long-term cost savings are identified;
- Provide "lessons learned" to the field and Army Headquarters and GWETER;
- Produce cost savings of 10 to 20 percent and make systems more cost-effective.

An effectiveness review team is made up of individuals experienced in the design, operation and optimization of pump-and-treat systems, as well as in the regulatory aspects of Record of Decision (RoD) development and modification. Depending on the installation's technical and regulatory situations, the team uses different mixes of in-house and outside experts. The disciplines that might be required include:

- Groundwater modeling and hydraulic optimization
- Hydrogeology



- Environmental law and RoD development
- Process and chemical engineering
- Innovative technology
- Risk assessment
- Natural attenuation processes
- Community relations.

A contractor handles the team's administrative requirements, such as collecting data, preparing the site for the visit and preparing reports. Team members could be drawn from the U.S. Army Environmental Center; the Army Center for Health Promotion and Preventive Medicine; the Groundwater Modeling Support Program at the U.S. Army Engineer Research and Development Center-Waterways Experiment Station; the U.S. Army Corps of Engineers Hazardous, Toxic, and Radioactive Waste Center of Expertise; the U.S. Geological Survey; Environmental Protection Agency laboratories; the Department of Energy; and nongovernmental entities. Local regulatory agencies and community representatives may be involved in the later stages of a site visit.

ACCOMPLISHMENTS AND RESULTS

Teams examined six pump-and-treat systems during the past year. These included Riverbank Army Ammunition Plant (AAP), California; the former Sacramento Army Depot (AD), California; Milan AAP, Tennessee; Picatinny Arsenal, New Jersey; Fort Devens, Massachusetts; and Pueblo CD, Colorado. The teams identified approximately \$75 million in potential lifecycle cost avoidances.

Examples of these cost avoidances can be seen at the Milan AAP proposed OU-4 system. The GWETER process identified that a change in the location of the reinjection field would save approximately \$5 million in capital costs and \$250,000 a year in operation and maintenance expenses. In addition, the use of the reinjected clean water at the installation boundary is predicated to speed the cleanup of the offpost areas by at least 5 years, leading to about \$1 million in savings.

At the former Sacramento AD, the team identified that the pretreatment of extracted groundwater was no longer necessary to meet standards. The shutting off of this pretreatment step would save at least \$100,000 a year in operating costs.

LIMITATION

Reviews are labor intensive, and only a few can be accomplished each year.

POINT OF CONTACT

Ira May

PROGRAM PARTNERS

U.S. Army Environmental Center
Major Army commands
Installations with operating or proposed pump-and-treat systems.

PUBLICATION

Evaluation of the Effectiveness of Existing Groundwater and Soil Treatments.
Army Science Board. 1998.



◆ **GROUNDWATER MODELING SYSTEM AND SUPPORT CENTER**

When it comes to groundwater treatment, state-of-the-art tools and techniques can save installations vast amounts of money. The Groundwater Modeling System (GMS) and Support Center provides technical expertise to installations and other users of groundwater modeling technologies.

PURPOSE

To provide groundwater modeling technical expertise to installations and other users of groundwater modeling technologies.

BENEFITS

State-of-the-art modeling can save vast amounts of money, as can a system to help ensure that proper remedial actions are carried out.

TECHNOLOGY USERS

Army installations and U.S. Army Corps of Engineers districts.

DESCRIPTION

The Groundwater Modeling Technical Support Program, sustained jointly by the U.S. Army Environmental Center (USAEC) and the U.S. Army Corps of Engineers Military Programs Office (CE-MP), has been assisting agencies and Army installations for several years. The program is administered by the Groundwater Modeling Technical Support Center at the U.S. Army Engineer Research and Development Center-Waterways Experiment Station (WES) and is overseen by a technical advisory group from the funding agencies. The program has provided technical expertise and products to a rapidly expanding group of users, evidenced by over 3,000 support calls during the last three years. The technical expertise made available through the program has led to more efficient remediation projects.

Many of the calls have come from Army installations looking for Department of Defense GMS support. The GMS was developed specifically to address groundwater remediation projects in the U.S. Army. Although USAEC has been the largest supporter of the system, other agencies, including the Environmental Protection Agency (EPA) and the Department of Energy (DOE), have recently followed the Army lead by supporting GMS technology.

Consequently, several federal and local government agencies have accepted GMS as their standard modeling system for addressing groundwater remediation. The GMS has over 800 users in the United States and is accepted by the EPA's Superfund and Wellhead Protection programs. The EPA also uses GMS in all 10 of its regional offices.

The rapid increase in technical support requests demonstrates widespread acceptance of GMS technology. The acceptance is largely based on the system's advanced technology and its development by government institutions such as USAEC, CE-MP, WES and the EPA. Equally significant are the high quality-control standards and technical support programs that ensure the maintenance and improvements necessary for software longevity – an important consideration for installations where cleanup actions can take many years.



ACCOMPLISHMENTS AND RESULTS

- Continued providing groundwater modeling technology transfer assistance to Army users. This support included distributing GMS software and manuals, and providing training as needed.
- Provided groundwater-modeling assistance to the Army's independent technical reviews (ITR) and Groundwater Extraction and Treatment Effectiveness Reviews (GWETER) programs.
- Provided telephone support and onsite technical assistance, as necessary, to installations conducting groundwater remediation activities. Site assistance was typically limited to less than one man-week of labor (per site) and travel costs.
- Demonstrated the utility of optimization at Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.
- Demonstrated the capability and cost-effectiveness of natural attenuation modeling in reducing remediation costs. This was accomplished by reducing the number of years required for active remediation systems such as pump-and-treat.
- Distributed results from the demonstration projects to installation personnel to ensure technology transfer within the Army.
- Provided groundwater-modeling services to Milan Army Ammunition Plant (AAP), Tennessee; Longhorn AAP, Texas; Fort Drum, New York; and Aberdeen Proving Ground, Maryland.

LIMITATION

Due to resource limitations, not all installations have been able to receive assistance from the center.

FOLLOW-ON PROGRAM REQUIREMENT

USAEC's institutional support is necessary for the continued success of the program.

POINT OF CONTACT

Ira May

PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Engineer Research and Development Center-Waterways Experiment Station
U.S. Army Engineer Research and Development Center-Cold Regions Research and Engineering Laboratory
Headquarters, U.S. Army Corps of Engineers

PUBLICATIONS

Development of a Groundwater Model for the Cold Regions Research and Engineering Laboratory (CRREL) Hanover, New Hampshire, 1999.

Groundwater Modeling System, Version 2.1.



◆ **IN-SITU ELECTROKINETIC REMEDIATION FOR METALS-CONTAMINATED SOILS**

Remediating heavy metals in environmentally sensitive areas presents a challenge to the Department of Defense (DoD). Often, these sites are used as wildlife habitats and public recreation areas. Technologies such as electrokinetic remediation allow for non-intrusive remediation.

PURPOSE
BENEFITS
TECHNOLOGY USERS
DESCRIPTION

To demonstrate the use of electrokinetic remediation for in-situ extraction of heavy metals from soil.

Electrokinetic remediation is potentially less invasive in ecologically sensitive areas and more cost-effective than other metals-removal technologies.

Military installations with metals-contaminated soils.

Military activities are primary contributors to metals contamination in soil. Military operations, such as small arms training, electroplating and metal finishing, explosives and propellant manufacturing and use, and use of lead-based paint, have resulted in vast areas of contaminated land. This creates a need for cost-effective remediation tools. Current technologies include excavation and solidification/stabilization methods, followed by landfilling of the contaminated soils. These methods are expensive and may provide only a temporary solution. A low-cost method of extracting contaminants from soil without excavation is needed to effectively address this problem. Electrokinetics has been identified as a possible method of performing in-situ extraction of metals from soil.

Heavy metals are an environmental problem, especially in aqueous conditions. Because mobile metal ions are charged particles, it is possible to use an electric current to move those particles.

The electrokinetic process is an in-situ continuous process that can be used to remove or capture heavy metals, radionuclides, and selected organic pollutants from sands, silts, fine-grained clays and sediments.

Electrokinetics involves the use of electrodes arranged in cathode and anode arrays. The electrodes are positioned inside permeable, water-filled casings inserted in the soil. Energizing the electrodes initiates hydrated ionic movement through the soil and groundwater toward the electrodes. Through electromigration and electroosmosis, the contaminants are transported through the soil for recovery at the electrodes. The contaminant metals can either electroplate on the electrodes in the wells, or concentrate in the well electrolyte for removal.

The site selected for the full-scale electrokinetic soil remediation demonstration is at Point Mugu Naval Air Weapons Station (NAWS) in Ventura County, California. The installation is located about 50 miles northwest of Los Angeles and comprises approximately 4,500 acres. Point



Mugu NAWS is situated in the western portion of the Ventura Basin, with the Santa Monica Mountains directly to the east.

The demonstration area is known as Site 5, a large area where many industrial and military operations were conducted. The specific area of study is approximately a half acre in and around two waste lagoons in the center of Site 5. These unlined lagoons were used between 1948 and 1978 to receive wastewater discharge, which included up to 60,000 gallons of photovoltaic fixer, small quantities of organic solvents, rocket fuel, and approximately 95 million gallons of plating rinse water. The waste lagoons, located in a tidal marsh area, measure approximately 30 feet by 90 feet and range in depth from 4 feet to 5 1/2 feet. They are surrounded by a berm approximately 2 feet above the water level. The waste lagoons typically contain standing water, which fluctuates with the tides. The area around the pits is bounded by Beach Road on the south side and the tidal marsh on the remaining three sides.

An emergency action in 1994 removed approximately 117 cubic yards of material to limit exposure to resident and migratory birds and reduce the potential source of contamination for surface and groundwater. This area is inhabited by the light-footed clapper rail, a federal- and state-listed endangered species, as well as other species. Before the emergency removal, the levels of chromium, cadmium, copper, nickel and silver were high. After the emergency action, surface sampling in the lagoons indicated that cadmium and chromium levels still exceeded Total Threshold Limit Concentrations described in the California Code of Regulations (Title 22, Section 66261.24). Further excavation is not desired because of the site's ecological sensitivity. Other potential chemical contaminants of concern at the site include arsenic, beryllium, Aroclor-1260, tetrachloroethane, trichloroethene, manganese and fluoride. The presence of endangered species restricts activity.

ACCOMPLISHMENTS AND RESULTS

Operation and monitoring of the technology was initiated in March 1998 and continued until October 1998, with a temporary shutdown for six weeks from the end of June through mid-August due to contractual issues with the technology vendor (Lynntech, Inc.). In total, the system operated for 22 weeks. At the end of this period, the pH front was just beginning to appear. A project review conducted at this point determined that unknown factors (either system design, site soil characteristics, or both) were retarding the performance of the technology and that the technology required further investigation and development prior to full-scale implementation. On October 7, 1998, the electrokinetic demonstration at Site 5 was suspended.

In January 1999, Engineer Research and Development Center (ERDC) resumed operation of the electrokinetic system in test cell 1 to identify the factors that may be retarding the performance of the technology at the NAWS Point Mugu site and to improve design and operations. Throughout the operation of the electrokinetic system, monthly sampling was conducted to monitor for and control the release of the inorganic contaminants outside the defined treatment zone. The electrokinetic process effects on the existing organic contaminants



were believed to be inconsequential, and only quarterly monitoring was conducted to track process effects on volatile organic compounds (VOCs). Routine sampling began showing indications of trihalomethane accumulation in the shallow (3 to 5 foot) piezometer wells inside and outside the defined treatment area. Subsequent sampling revealed that trihalomethanes (with chloroform being the primary trihalomethane constituent) were accumulating in the shallow breakout wells outside the barrier wall at the site. Upon the discovery of trihalomethane contaminants, the sampling plan was modified to include the monitoring of VOCs (EPA Method 8260) and chlorine residual. Beginning in April 1999, sampling of the electrode wells in the treatment area revealed elevated levels of trihalomethanes and free chlorine in the electrolyte solution, thus indicating the electrokinetic system was the source of the trihalomethane production. This finding was verified in a laboratory treatability test cell operated at ERDC. The naturally occurring chlorides present at the site are being electrochemically transformed into free chlorine at the anode well electrodes. This chlorine is saturating the pore fluid and reacting with the naturally occurring organic material in the shallow soil layer. This reaction is believed to be forming the trihalomethane compounds detected at the site. During May 1999, mitigation steps were taken to control the trihalomethane release that included periodically pumping down the electrode wells and improved anode well air sparging to remove the free chlorine generated on the electrode. The June 1999 sampling shows the corresponding reduction in chloroform levels resulting from these actions.

While positive results appear to be developing with the mobility of cadmium and chromium, many issues remain to be resolved prior to the full-scale commercialization of electrokinetic remediation technology. Such issues include:

1. A better understanding of the technology's effects on naturally occurring ions and how these effects impact mobilization and removal of the target contaminants. Many discrepancies between the laboratory testing and the field test were identified. The retarding effects created by the naturally occurring ions can not be accurately quantified, and their effects on the type of metal species formed under the electric field influence cannot be accurately predicted. Metals species and ionic charges observed in the laboratory differed from those observed in the field. In addition to the retarding effects produced by the naturally occurring ions, the development of potentially hazardous by-products (e.g., chlorine, trihalomethanes and acetone), resulting from the application of an electric field on a soil containing these ions and means of inhibiting by-product production, requires further investigation.
2. Clear identification of the limitation of electrokinetic remediation. Laboratory testing may give a false indication of the applicability of electrokinetic remediation to a specific site. A means of identifying site-specific performance-limiting factors needs to be developed.
3. An improved methodology for predicting treatment performance.
4. A better understanding of the electrode design and its effects on electric field shape and intensity.



5. An improved methodology for determining the configuration of the electrodes under field conditions.

To address these needs, work continues at the Environmental Security Technology Certification Program (ESTCP) electrokinetic demonstration site under the direction of the ERDC research team. ERDC is conducting laboratory and pilot studies to resolve the identified research needs. Full-scale application of this technology for remediation of metals-contaminated soil is limited until the above issues can be resolved.

LIMITATIONS

Observations of the technology indicate numerous factors may inhibit its performance. These factors may include (but are not limited to) competition with non-contaminant ions (for mobilization), heterogeneity in the permeability of the soil within the treatment zone, and soil organic content.

FOLLOW-ON PROGRAM REQUIREMENTS

Further investigation into the identification and understanding of the in-situ factors that retard the performance of the technology. Once identified, methods to overcome the inhibiting effects of these factors must be developed.

POINT OF CONTACT

Gene Fabian

PROGRAM PARTNERS

U.S. Army Environmental Center
Point Mugu Naval Air Weapons Station, California
U.S. Army Engineer Research and Development Center-Waterways Experiment Station
Environmental Security Technology Certification Program
Naval Facilities Engineering Command, Southwest Division



INTRINSIC REMEDIATION STUDY OF POL-CONTAMINATED SITES

Many operational facilities have groundwater contaminated with petroleum, oils and lubricants (POLs). Remediation options include excavation and pump-and-treat operations that are expensive and can disrupt Army operations. Intrinsic remediation allows for the least-expensive cleanup of contaminated groundwater with no impact on current operations.

PURPOSE

To transfer intrinsic remediation technology from the Air Force for use in remediating POL-contaminated sites on Army installations.

BENEFITS

Intrinsic remediation has widespread potential application because native organisms can degrade a variety of petroleum products, including jet fuel, gasoline, diesel fuel and heating oils. In-situ treatment of fuel contaminants in groundwater greatly reduces the expense and inconvenience associated with traditional pump-and-treat methods. Intrinsic remediation also eliminates the



need for expensive off-gas treatment often required with in-situ air sparging. It produces harmless byproducts and does not interfere with ongoing site operations. There is no equipment to maintain, and it can be applied to inaccessible areas. Intrinsic remediation is supported by the American Society for Testing and Materials (ASTM) Guide for Risk-Based Corrective Action (RBCA).

TECHNOLOGY USERS

Army installations.

DESCRIPTION

Intrinsic remediation is the reduction of contaminant concentration in the environment through existing biological processes (aerobic and anaerobic biodegradation), physical phenomena (advection, dispersion, dilution, diffusion, volatilization, sorption/desorption) and chemical reactions (ion exchange, complexation, abiotic transformation). Geologic, hydrogeologic, chemical and biological site information is used to model the contaminant degradation rates and pathways.

During intrinsic remediation, the contamination plume undergoes aerobic (oxygen) bioremediation followed by anaerobic (nitrate, iron, sulfate and methane) bioremediation by indigenous microbes. No added cultures or nonnative organisms are used. No external means are employed to speed up remediation; natural means completely govern the process. Intrinsic remediation is accepted as a remedial alternative in 37 states and in all 10 Environmental Protection Agency regions.

ACCOMPLISHMENTS AND RESULTS

In September 1998, field sampling to collect data for the intrinsic remediation model was conducted at a contaminated groundwater site at Fort Jackson, South Carolina. The data collected was used to model the contaminant degradation rates and pathways. During the site investigations, contaminants were found to be leaching into a nearby stormwater drainage pipe. Because of this, a potential receptor exposure pathway existed. In this case, intrinsic remediation alone was not considered acceptable. Fort Jackson is using the data collected to support a corrective action plan that incorporates an engineered contaminant extraction method to cut off the exposure pathway coupled with intrinsic remediation.

LIMITATIONS

- High contaminant concentrations (total petroleum hydrocarbon levels greater than 25,000 parts per million may necessitate source removal)
- Potential impact to human and ecological receptors
- State regulatory reluctance
- Insufficient microbial activity
- Lack of geologic and hydrogeologic homogeneity (which results in inaccurate contaminant mobility modeling)
- Long remediation periods.

FOLLOW-ON PROGRAM REQUIREMENT

Use the report results to provide technical support for the corrective action plan that includes limited source removal and natural attenuation with long-term monitoring during regulatory negotiations.

POINT OF CONTACT

Gene Fabian



PROGRAM PARTNERS

U.S. Army Environmental Center
Fort Jackson, South Carolina

**OPTIMIZATION OF IN-SITU VOLATILIZATION DEVICES**

Many Army installations use soil vapor extraction (SVE) to remove volatile compounds from soil, mainly because they can leave the soil in place during the cleanup operation and save money. This project is developing a model that installations can use to improve the design and operations of such in-situ remediation systems.

PURPOSE

To develop a three-dimensional vadose-zone model to assist in the optimization of in-situ volatilization systems.

BENEFITS

This model will be useful at both the design stage (to determine optimal vent spacing, depths and flow rates) and the operational phase (to determine optimal time of system operation and to balance the systems) of in-situ volatilization systems.

TECHNOLOGY USERS

Installations with operating or proposed in-situ volatilization systems.

DESCRIPTION

Many Army sites have subsurface contamination problems stemming from disposal of volatile organic compounds (VOCs). SVE has often been used to remediate the unsaturated zone, mainly because it leaves the soils in place during the cleanup process and results in large cost savings. Field implementation of SVE systems has often proceeded without the benefit of numerical modeling to provide an optimal engineering design and estimate the time required for cleanup.

The U.S. Army Environmental Center (USAEC) is conducting characterization and cleanup activities at Twin Cities Army Ammunition Plant (TCAAP), Minnesota, to remediate contaminated soils, sediments and groundwater. These remediation efforts include SVE systems at two sites to remove VOCs from soils and reduce contaminant migration to groundwater. The SVE systems have operated since 1987 and, according to sampling data, have removed large volumes of VOCs. They provide a platform to calibrate a new vadose-zone model and test proposed optimization concepts.

This study used site-specific data collected at TCAAP to develop a multidimensional, unsaturated numerical model for analyzing the effectiveness of SVE. The model was calibrated and validated, and used to assess the efficiency of the remediation systems, evaluate alternative designs, and determine possible improvements. As part of the study, sensitivity and importance analyses were conducted to identify the critical input parameters needed to simulate the SVE process. The results of this



study will be used to bridge the gap between using empirical correlation and field experience for system design and using numerical modeling for evaluating system performance and design.

ACCOMPLISHMENTS AND RESULTS

Based on the modeling results, it appears that the SVEs at TCAAP removed within the first three years the VOCs in the vadose zone that are available for transport to the groundwater. Since that time, the SVEs have been removing VOCs from the surface of the groundwater table and have adsorbed VOCs in the vadose zone. Due to the low cost of these systems, it is considered worthwhile to use the SVE to aid in the remediation of the groundwater, which might not be the case at other environmental situations.

A paper on study results was presented at the 1999 American Society of Civil Engineers, Water Resources Division meeting in Phoenix, Arizona. A draft final report on the study was completed in September 1999.

LIMITATION

The model will need to be extended to handle the uncertainties involved in sites that do not have all the data necessary to take advantage of the optimization concept.

POINT OF CONTACT

Ira May

PROGRAM PARTNERS

U.S. Army Environmental Center
Argonne National Laboratory
Twin Cities Army Ammunition Plant, Minnesota

PUBLICATIONS

May, I.P., Z. Jiang, and L.A. Durham. "Evaluation of the Soil Vapor Extraction System at the Twin Cities Army Ammunition Plant: A Post-Audit Assessment." ASCE presentation. June 1999.

Williams, G.P., D. Tomasko. and Z. Jiang, 1999, *Twin Cities Army Ammunition Plant Soil Vapor Extraction System: A Post-Audit Modeling Study*, Argonne National Laboratory, Final Draft.



PHYTOREMEDIATION OF EXPLOSIVES IN GROUNDWATER USING CONSTRUCTED WETLANDS

Many Department of Defense (DoD) sites contain explosives-contaminated groundwater. Demonstrating cost-effective methods to treat this contamination will allow installations to conduct restoration using reliable, accepted and effective processes. Phytoremediation, the use of plants and microbes to degrade explosives, provides an opportunity to treat large volumes of groundwater at lower costs.

PURPOSE

To demonstrate the use of phytoremediation as an alternative technology.



BENEFITS

Phytoremediation destroys organic contaminants in groundwater at lower costs; the savings can be applied to other installation operations or restoration efforts.

TECHNOLOGY USERS

Army and DoD installations with explosives-contaminated groundwater.

DESCRIPTION

Current groundwater cleanup technologies, such as granular activated carbon (GAC) and advanced oxidation, are labor-intensive and costly. GAC requires additional disposal. Ultraviolet oxidation systems require significant capital investment, labor and utilities expenses for the life of the project.

An alternative such as phytoremediation can provide lower maintenance and capital costs. Typically, a GAC system costs \$2 million to \$8 million for construction and \$1.5 million annually (for 30 years) per site. Cost-performance data indicates that for surface water discharge, a gravel-based wetland yields capital costs of \$330,000 per acre and \$6,000 an acre (per year) to operate and maintain. For a site treating 500,000 gallons per week, the potential cost savings are \$2 million.

Milan Army Ammunition Plant (MAAP) in Milan, Tennessee, was the site of the field demonstration. Prior efforts by the Environmental Protection Agency (EPA) identified the plant enzyme nitroreductase as able to degrade Trinitrotoluene (TNT).

In the initial phase of the project, plants native to Tennessee that contain the enzyme were challenged with explosives-contaminated water from the site. The three submergent and three emergent species that best reduced TNT and Cylonite (RDX), along with parrotfeather, were selected for the second phase.

Two distinct systems were constructed in the second phase: lagoon and gravel-based. The lagoon system, consisting of two cells in a series, was planted with submergent species in 2 feet of groundwater. The groundwater was treated by the plants, naturally occurring microbes and sunlight. The gravel-based wetland contained emergent plant species in both cells. The first cell was operated anaerobically (to degrade RDX) and the second cell was aerobic. This aerobic cell was a reciprocating wetland. Reciprocation, the movement of water between cell compartments, further enhances water quality.

Phytoremediation can be used as a pretreatment for other technologies or as a final "polishing" technology.

ACCOMPLISHMENTS AND RESULTS

Both wetland systems operated from June 1996 to September 1997. The lagoon system was not effective in degrading RDX under the demonstration parameters. Initially, the lagoon system degraded TNT, but as plant growth suffered, photodegradation was a major factor in TNT degradation. The system, requiring more attention in coaxing submergent species to grow in the contaminated groundwater, did not rebound and was taken out of operation in September 1997.



The gravel bed system was more effective in degrading TNT and RDX. On average, the gravel bed system reduced explosives residues with 95 percent or greater efficiency. TNT contaminants were reduced from 4,000 parts per billion (ppb) to less than 2 ppb, and total explosives were reduced from 10,000 ppb to less than 50 ppb. From October 1997 to July 1998, the gravel bed system operated under parameters that would allow for the design of a 200 gallon-per-minute (gpm) facility at the installation. The design and cost analysis for such a facility are included in the final report.

This demonstration has shown an approximate 56 percent cost avoidance in using constructed wetlands over granular media filter (GMF)/GAC. Amortized over 30 years, wetlands yield \$1.82 per kgal of water, of which \$1.52 is for operation and maintenance. GMF/GAC yields \$3.97 per kgal, of which \$3.39 is operation and maintenance.

A final report has been completed and approved by the Environmental Security Technology Certification Program (ESTCP). A cost-and-performance report has also been approved by the ESTCP and will be available through the ESTCP Web site.

LIMITATIONS

Cool weather, time constraints and space requirements may limit use of phytoremediation in constructed wetlands.

**FOLLOW-ON PROGRAM
REQUIREMENT**

Technology transfer efforts must continue.

POINT OF CONTACT

Darlene F. Bader

PROGRAM PARTNERS

U.S. Army Environmental Center
Tennessee Valley Authority
U.S. Army Engineer Research and Development Center-Waterways
Experiment Station

PUBLICATIONS

Demonstration Results of Phytoremediation of Explosives-Contaminated Groundwater Using Constructed Wetlands at the Milan Army Ammunition Plant, Milan, Tennessee. SFIM-AEC-ET-CR-97059.

Phytoremediation of Explosives-Contaminated Groundwater in Constructed Wetlands: II-Flow Through Study. SFIM-AEC-ET-CR-96167.

Phytoremediation of Explosives-Contaminated Groundwater in Constructed Wetlands: I-Batch Study. USAEC Report SFIM-AEC-ET-CR-96166.

Demonstration Plan for Phytoremediation of Explosives-Contaminated Groundwater in Constructed Wetlands at Milan Army Ammunition Plant, Milan, Tennessee: Volume I and II. SFIM-AEC-ET-CR-95090.

Evaluation of Various Organic Fertilizer Substrates and Hydraulic Retention Times for Enhancing Anaerobic Degradation of Explosives-Contaminated



Groundwater while Using Constructed Wetlands at the Milan Army Ammunition Plant, Milan, Tennessee. SFIM-AEC-ET-CR-98031.

◆ PHYTOREMEDIATION OF LEAD IN SOIL

Because it can leach into groundwater or surface water, lead in soil can jeopardize the continued operation of training ranges. Phytoremediation, the use of plants to remove or degrade contaminants from various environmental media, offers a reliable method for removing lead from soil.

PURPOSE

To demonstrate the effectiveness of phytoremediation – specifically phytoextraction – in removing lead from soil.

BENEFITS

Benefits from successful phytoremediation of lead-contaminated sites are lead removal from the soil and lead recovery for offsite disposal or potential recycling, which allows for nonrestrictive site use. Future costs of monitoring and maintaining a hazardous site or landfilled hazardous waste would be eliminated, as would the long-term liability associated with hazardous waste. Phytoremediation minimizes site disturbance and limits dispersal of contaminants, in contrast to excavating and landfilling soil.

Phytoremediation also costs much less than conventional methods. Phytoremediation of 1 acre to a depth of 50 centimeters is estimated to cost \$60,000 to \$100,000. Excavating and landfilling the same amount of soil is estimated to cost \$400,000 to \$1.7 million.

TECHNOLOGY USERS

Army and Department of Defense (DoD) installations with lead-contaminated soil.

DESCRIPTION

Disposal and burning of scrap ammunition and powder, firing range use and similar activities have resulted in lead-contaminated soils at many DoD installations. Current treatments include excavation and landfilling, soil washing, or immobilization through chemical treatment. As a result, the metals are neither destroyed nor reclaimed. Liability, long-term monitoring and restricted land use all contribute to high costs.

Phytoremediation, specifically the technique of phytoextraction, is an alternative technology. Phytoextraction is the use of plants to pull metals out of the soil solution and into the plant structure. Process optimization and treatability studies conducted by the Tennessee Valley Authority (TVA) have determined the most efficient plant species, leachate concerns, levels of soil amendments, amendment application and fertilization effects on lead accumulation and extraction.

This project is demonstrating the use of phytoextraction at Twin Cities Army Ammunition Plant (TCAAP) in Arden Hills, Minnesota. TVA conducted optimization and treatability efforts before designing the field demonstration.



Two 0.2-acre sites were selected for the demonstration. One site contained low concentrations of lead (740 parts per million [ppm]); the other had moderate lead concentrations (3,500 ppm). Two crops were planted on each site: corn in May 1998 and white mustard in August 1998. At the appropriate time in the growth cycle of each crop, soil amendments were applied to encourage uptake of lead. The crops were harvested and transported to a smelter. In 1999, a single crop of silage corn was planted, harvested and smelted. The demonstration is expected to continue for a single crop in 2000.

The U.S. Army Environmental Center (USAEC) and the DoD Environmental Security Technology Certification Program have provided funding.

ACCOMPLISHMENTS AND RESULTS

The interim guidance document reported 1998 results with an average lead concentration in corn of 0.65 percent and 0.13 percent for the two sites. Lead concentrations in the white mustard averaged 0.083 percent and 0.034 percent for the two sites. In 1999, a silage corn variety was planted for its greater biomass. Due to extreme wet conditions in the mid-West, the corn production was not optimal, resulting in a reduced plot area for phytoextraction. Samples are currently being processed and analyzed. Due to the poor weather conditions, another crop of silage corn will be planted in 2000.

LIMITATIONS

Time constraints, as well as the depth and degree of contamination, is one limitation. Another limitation may be the length of the growing season and the availability of soil amendments in large quantities. Extreme weather conditions, resulting in poor crop growth, will impact the effectiveness of this technology.

POINT OF CONTACT

Darlene F. Bader

PROGRAM PARTNERS

U.S. Army Environmental Center
Twin Cities Army Ammunition Plant, Minnesota
Tennessee Valley Authority
Alliant TechSystems

PUBLICATIONS

Results of the 1998 Field Demonstration and Preliminary Implementation Guidance for Phytoremediation of Lead-Contaminated Soil at the Twin Cities Army Ammunition Plant, Arden Hills, Minnesota.
USAEC SFIM-AEC-ET-CR-99001.

Technology Demonstration Plan for Phytoremediation of Lead-Contaminated Soil at the Twin Cities Army Ammunition Plant, Arden Hills, MN. USAEC Report SFIM-AEC-ET-CR-98008.

Test Plan for the Phytoremediation Studies of Lead-Contaminated Soil from the Sunflower Army Ammunition Plant, DeSoto, Kansas. USAEC Report SFIM-AEC-ET-CR-96198.

Results of a Greenhouse Study Investigating the Phytoextraction of Lead from Contaminated Soils from the Sunflower Army Ammunition Plant, DeSoto, Kansas. USAEC Report SFIM-AEC-ET-CR-98036.



◆ RANGE RULE RISK METHODOLOGY

The Department of Defense (DoD) has proposed a Range Rule that identifies a process for evaluating appropriate response actions on closed, transferred and transferring ranges. The U.S. Army Environmental Center (USAEC) is developing a methodology – known as the Range Rule Risk Methodology (R3M) – that will help the DoD assess health and environmental risks posed by these ranges.

PURPOSE

To develop a risk management and assessment methodology for use in implementing the Range Rule.

BENEFITS

The R3M will serve as the DoD method for evaluating ranges under the Range Rule. It also may be used to evaluate unexploded ordnance (UXO) on ranges not covered specifically by the Range Rule and as a framework in parallel evaluations of human health risks stemming from physiologic and physical injuries.

TECHNOLOGY USERS

DoD ranges being evaluated under provisions of the Range Rule.

DESCRIPTION

DoD has drafted a Range Rule that identifies a process for evaluating appropriate response actions on closed, transferred and transferring ranges. Response actions will address safety, human health and the environment. The Range Rule contains a process that is consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and tailored to the special risks posed by military munitions and ranges. This process includes range identification, range assessment, range evaluation, recurring reviews, and range closeout.

To satisfy this process, USAEC is developing a multicomponent risk evaluation methodology – R3M – that includes a risk management strategy, risk management framework, risk assessment methods and risk communication tools.

Many R3M components come directly from other methods used in range evaluation and response actions. The R3M effort serves to combine – or improve and develop – the necessary elements into a cohesive process that will be fully reviewed and approved by all DoD components and the Environmental Protection Agency (EPA).

The project includes several steps:

- Develop an interim method consisting of qualitative and semi-quantitative tools to reduce risks while meeting Range Rule requirements;
- Coordinate development with DoD, the EPA, the Range Rule Partnering Initiative and the public;
- Support partnering initiatives and Public Information Forums;
- Gain DoD and EPA acceptance of an interim R3M before promulgation of the Range Rule;



- Further develop, test, and validate R3M elements during the early years of Range Rule implementation;
- Revise the R3M based on testing and validation and prepare a final R3M, which includes methods to evaluate sites relative to closeout criteria.

ACCOMPLISHMENTS AND RESULTS

- Draft a “strawman” method reviewed by DoD and EPA R3M teams.
- Developed a draft interim R3M based on DoD, EPA and partnering initiative team input.
- Developed a Preliminary Validation plan for testing R3M prior to Range Rule promulgation.

FOLLOW-ON PROGRAM REQUIREMENTS

- Conduct an interim R3M Preliminary Validation effort.
- Approve release of draft R3M for public availability.
- Continue development of interim R3M through input from validation results and DoD, EPA, partnering initiative team and public input.
- Conduct final R3M development program.

POINT OF CONTACT

Scott Hill

PROGRAM PARTNERS

U.S. Army Environmental Center
 Department of Defense
 Environmental Protection Agency
 Range Rule Partnering Initiative

PUBLICATIONS

Public Information Forum fact sheets on the Range Rule.



REMEDICATION OF TRICHLOROETHYLENE-CONTAMINATED AIR STREAMS USING BIOFILTRATION

Air stripping is an effective method of removing volatile compounds from water, but the volatile compounds must be controlled to prevent their release into the atmosphere. Biofiltration provides effective and total treatment at reasonable costs. Biofiltration of trichloroethylene (TCE)-contaminated air streams can destroy such contaminants without creating secondary waste streams. Biofiltration will allow depots to support Department of Defense (DoD) operations at lower costs.

PURPOSE

To demonstrate biofiltration’s effectiveness in destroying TCE removed from groundwater on a production-scale system at Anniston Army Depot, Alabama.

BENEFITS

Biofiltration will destroy contaminants without producing a secondary waste stream. Early economic evaluations predict that biofiltration will be less expensive than granular activated carbon (GAC). The system could be adapted to other industrial operations that produce solvent-contaminated air streams.



TECHNOLOGY USERS

Any DoD operations discharging solvent-contaminated air.

DESCRIPTION

Five Army installations and several Air Force bases currently use packed-column air strippers. Capture of TCE and other chlorinated solvents on GAC is effective, but expensive. Some air-stripper systems discharge to the air – which may be prohibited under new air regulations – and some capture the off gas on GAC. Biofiltration offers the ability to destroy air contaminants without producing a secondary waste stream.

The biofilter system is a scaled-up version of a 3 cubic-feet-per-minute system operating for three years at the Tennessee Valley Authority (TVA) to test different volatile compounds. The system uses propane gas as a co-substrate to feed the microorganisms, alternately feeding propane and TCE or other solvents. This system will handle methylene chloride and other compounds that are toxic to methanotrophic systems. The filter bed is made of pelletized, composted chicken litter, pine bark, and chopped kenaf with pulverized limestone as a buffering agent. The bed at TVA has operated without additional materials or changes.

The Anniston Army Depot project consists of three phases: design, installation and testing. The design phase included the design and procurement of a system to treat 100 cubic feet per minute. The installation phase included installation of the system at one of the depot's air stripper systems. The treatment phase included biofilter startup, acclimation, and operation for approximately 14 months. System acclimation required approximately six weeks once the bed was inoculated with microorganisms.

The operational period will allow for testing all system parameters, such as varying the contaminant concentration in the feed air stream, excess moisture and dry conditions in the biofilter, winter-to-summer temperature extremes, and the degree to which the system can be automated.

ACCOMPLISHMENTS AND RESULTS

The test and safety plans were prepared and approved. The equipment design was completed, the equipment procured and assembled, and the system installed at Anniston Army Depot. The system was ready for inoculation in November 1996, when Anniston Depot personnel notified TVA that the Environmental Protection Agency was going to conduct an installation groundwater dye test and that all pumps would be stopped until spring 1997.

The dye test was extended to July 1997. To avoid further delay, the state gave permission to feed surrogate TCE-contaminated air to the system to complete the acclimation period and initiate startup of the biofilter system.

The filter bed was inoculated; propane and surrogate feed were initiated to acclimate the bed and to obtain startup data. Initial data indicated TCE removal rates equal to or above those seen in smaller-scale tests at TVA.



An Integrated Services Digital Network (ISDN) telephone line with voice and high-speed data transfer channels was installed to transfer data electronically from the site to TVA and to remotely control the onsite gas chromatograph. System optimization testing using depot groundwater as the TCE source was completed. Continuous operation was completed using the optimum parameters developed during the testing.

Testing was completed in July 1999.

FOLLOW-ON PROGRAM REQUIREMENTS

- Prepare a technical report.
- Complete the brochure and video.

POINT OF CONTACT

Wayne Sisk

PROGRAM PARTNERS

U.S. Army Environmental Center
Tennessee Valley Authority
Anniston Army Depot, Alabama



REMEDIATION TECHNOLOGIES SCREENING MATRIX AND REFERENCE GUIDE

Many government agencies produced documents to help their environmental project managers make intelligent decisions on cleanup technologies, but a lack of coordination led to duplication of effort among these agencies. The Federal Remediation Technologies Roundtable (FRTR) developed a guide to serve as a neutral platform from which to evaluate technologies.

PURPOSE

To monitor and update the *FRTR Remediation Technologies Screening Matrix and Reference Guide, Version III*. Distribute full-size screening matrix posters as a quick guide to technology groups' ability to handle contaminants.

BENEFITS

The guide is an unbiased medium in which users can find information to save them time and effort. The guide is also recognized as a comprehensive source for environmental restoration technology information.

TECHNOLOGY USERS

Remediation project managers, government agencies, private organizations and academia.

DESCRIPTION

In the past, numerous government agencies, divisions and branches produced documents as tools for their environmental project managers. The FRTR sponsored production of the *FRTR Remediation Technologies Screening Matrix and Reference Guide, Version III* to eliminate the duplication of effort among its member agencies.

The document is electronic, allowing for quick and easy updating. The update effort committed Roundtable members to work together, leverage funds and resources, and prevent duplication of effort.



Technologies included in the guide were selected by the committee representatives, who had the option to serve as a review entity for each technology. After the document was written and reviewed, the information was formatted in HTML, integrated with all necessary hyperlinks and placed on the Internet for universal use.

The current World Wide Web version of the *FRTR Remediation Technologies Screening Matrix and Reference Guide*, located on the FRTR home page, replaced Version II. Web technology affords the Roundtable the opportunity to update and modify this "living" document. Each week, the guide is reviewed for broken links and outdated or incorrect information. New information is reviewed and evaluated for validity. This regular maintenance ensures the document's integrity.

ACCOMPLISHMENTS AND RESULTS

This project helps to demonstrate and foster cooperation among many federal agencies. Committee members established the personal relationships necessary to coordinate the update effort. There was a successful leveraging of funds from the Navy and Air Force. The Environmental Protection Agency donated significant support. Other agencies dedicated numerous in-house personnel hours toward the effort.

The document was released on the Web at www.frtr.gov/matrix2top_page.html during November 1997. A poster version of the Screening Matrix became available in June 1998.

LIMITATIONS

The document is an electronic Web file, so there is no conveniently accessed paper version. Links and information must be continually monitored.

FOLLOW-ON PROGRAM REQUIREMENTS

- Coordinate and execute continued update efforts.
- Continue to obtain committee concurrence.
- Provide long-term maintenance and monitoring.
- Distribute matrix posters.

POINT OF CONTACT

Dennis Teefy

PROGRAM PARTNERS

U.S. Army Environmental Center
Federal Remediation Technologies Roundtable
Naval Facilities Engineering Service Center
Air Force Center for Environmental Excellence
Environmental Protection Agency
U.S. Geological Survey
Department of Energy

PUBLICATIONS

Federal Remediation Technologies Screening Matrix and Reference Guide, Version III. November 1997.

Federal Remediation Technologies Screening Matrix poster. June 1998.



◆ **SLURRY BIOTREATMENT OF
EXPLOSIVES-CONTAMINATED SOILS**

Army industrial installations face high costs in cleaning up soil contaminated by past explosives operations. Remediating these sites is a prerequisite for environmental protection and beneficial reuse by the Army. These installations require cost-effective techniques to treat large volumes of explosives-contaminated soils. The U.S. Army Environmental Center (USAEC) has tested soil slurry biotreatment, or bioslurry, as an alternative to incineration.

PURPOSE

To prove that biodegradation of explosives contamination in a soil slurry bioreactor is both possible on a large scale and an affordable alternative to incineration.

BENEFITS

Contaminated soil can be treated and returned to its original location.

TECHNOLOGY USERS

Department of Defense (DoD) installations containing areas of explosives-contaminated soils.

DESCRIPTION

Past production and handling of conventional munitions left explosives at many Army installations. Depending on the concentrations of explosives – mainly trinitrotoluene (TNT), Royal Demolition Explosive (RDX) and cyclotetramethylene (HMX) – the affected soils can pose reactivity and toxicity hazards. Because these explosives can migrate from the soils into groundwater, the affected soils should be treated to eliminate threats to human health or the environment. Incineration, the traditional cleanup technology, is expensive and not readily accepted by regulators or the public.

The Army has searched since the 1980s for alternatives to incineration. Extensive tests have shown that bioremediation – the use of living organisms to remove pollutants from soil or water – can be a cost-effective treatment method. Biotreatment processes involve providing favorable conditions to enhance microbial metabolism, which can result in degradation of materials such as explosives, fuels, and solvents.

The USAEC has field-tested several bioremediation methods, including windrow composting and soil slurry reactor biotreatment.

In 1995, USAEC conducted a soil slurry bioremediation test at Joliet Army Ammunition Plant (JOAAP), Illinois. Argonne National Laboratory performed the test. Conditions were established to encourage microorganism growth and demand for the contaminants. Because the process maintains optimal conditions and the slurry is mixed to maintain contact between the microorganisms and contaminants, slurry processes are faster than many other biological processes.

Bioslurry technology requires soil excavation and screening to remove large rocks and plant roots; mixing soil with water to form a slurry in a reactor; and removal of the slurry from the reactor. Explosives degradation also requires a



co-substrate (e.g., molasses), pH between 6 and 7, and aerobic/anoxic operation.

In this study, the native microbial population degraded explosives in soil. Four reactors (380 gallons each) were operated at JOAAP: a control reactor with no co-substrate; 20 percent and 10 percent weekly replacement (by volume) reactors; and a 5 percent daily replacement reactor. This design allowed investigation of different soil (and TNT) loading rates. The target soil slurry was 15 percent (weight/weight). Explosives concentrations in the soil were 2,000 to 8,000 mg/kg. Environmental conditions were identical for all reactors; temperature, pH, and dissolved oxygen were similar.

ACCOMPLISHMENTS AND RESULTS

At JOAAP, aerobic/anoxic bioslurry was used to reduce TNT, HMX and RDX concentrations in soil. Chemical analyses showed that soil slurry biotreatment of explosives-contaminated soil removed more than 99 percent of the contaminants. Metabolic fate studies of field samples showed up to 20 percent of the contaminant was completely mineralized and released as CO₂. Another 55 percent of the contaminant showed up as organic acids and carbon fragments in the biomass, indicating a high degree of contaminant breakdown.

Other results:

- Aerobic/anoxic cycling enhances degradation (minimizes accumulation of metabolic intermediate byproducts).
- The product is suitable for land application.
- Process water can be recycled.
- Molasses was the most potent and cost-effective co-substrate.
- Degradation activity slows below 20°C.

The biological process is robust and can adapt to a variety of soil concentrations and temperatures. During normal operating conditions, soil loading can be increased to maximize throughput. In cold weather, minimizing additions of contaminated soil will enhance system survival.

In a separate study, USAEC examined the addition of surfactant to enhance the bioavailability of the contaminant in the solution. Treatability studies performed by the U.S. Army Engineer Research and Development Center – Waterways Experiment Station (WES) showed increased solubilization of TNT from soil with surfactant addition. USAEC field trials in 1995 using the same food-grade biodegradable surfactants showed faster initial reduction of TNT, but its byproducts accumulated in the reactor for longer periods, compared to biotreatment without surfactants. Consequently, process enhancements to bioslurry treatment of explosives-contaminated soils afforded by additional surfactant appear to be minimal.

In 1997, at Iowa Army Ammunition Plant (IAAAP), the DoD Environmental Security Technology Certification Program sponsored a field demonstration of aerobic/anoxic bioslurry treatment, side-by-side with a commercial anaerobic process, the Simplot Anaerobic Bioremediation Ex-situ (SABRE) process.



Lined lagoon reactors were scaled up to treat up to 80 tons of soil in a batch. The demonstration provided performance results, a conceptual engineering design and cost estimates for full-scale application of slurry biotreatment. This data also applies to other explosives-contaminated sites.

LIMITATIONS

- Oversized rocks and plant roots must be removed before bioslurry use.
- Organic co-substrate is needed.
- pH must be greater than 6 to 7.
- Cold temperatures slow microbial metabolism rate.

POINTS OF CONTACT

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Wayne Sisk

PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Engineer Research and Development Center-Waterways
Experiment Station
Joliet Army Ammunition Plant, Illinois
Iowa Army Ammunition Plant, Iowa

PUBLICATIONS

Feasibility of Biodegrading TNT-Contaminated Soils in a Slurry Reactor. Technical Report CETHA-TE-CR-90062. U.S. Army Toxic and Hazardous Materials Agency (prepared by Argonne National Laboratory). June 1990.

Feasibility of Biodegrading Explosives-Contaminated Soils and Groundwater at the Newport Army Ammunition Plant. Technical Report CETHA-TS-CR-92000. U.S. Army Toxic and Hazardous Materials Agency (prepared by Argonne National Laboratory). June 1991.

AVAILABLE IN PRINT AND ON CD-ROM:

A Laboratory Study in Support of the Pilot Demonstration of a Biological Soil Slurry Reactor. Technical Report SFIM-AEC-TS-CR-94038. U.S. Army Environmental Center (prepared by Argonne National Laboratory). July 1995.

Field Demonstration of Slurry Reactor Biotreatment of Explosives-Contaminated Soils. USAEC Report SFIM-AEC-ET-CR-96178. December 1996.

Biotreatment of Explosives-Contaminated Soils: Field Demonstration of Multiple Slurry Reactor Processes. USAEC Report SFIM-AEC-ET-CR-99009. June 1999.



II – COMPLIANCE TECHNOLOGY

◆ PINK WATER TREATMENT TECHNOLOGY RESEARCH TASK

Army ammunition plants produce explosives-contaminated water known as pink water. The plants meet discharge requirements by using granular activated carbon (GAC) to remove contaminants from pink water. The explosives-laden GAC – classified as a hazardous waste – is either regenerated or incinerated. Other treatment technologies are being sought to avoid the generation of this hazardous waste.

PURPOSE

To evaluate alternatives to GAC treatment of pink water.

BENEFITS

A cost-effective alternative to GAC absorption that does not generate hazardous waste when treating pink water will help Army installations meet stringent regulations pertaining to water effluent quality.

TECHNOLOGY USERS

Army ammunition plants.

DESCRIPTION

Army ammunition plants perform two functions that generate a waste stream known as pink water. These functions are (1) load, assemble and pack (LAP), and (2) demilitarization of munitions. Associated housekeeping and processing operations create the wastewater stream. Typical sources are wash down and wash out of munitions and laundering workers' clothing. Pink water typically contains photochemically active trinitrotoluene (TNT). The photoreactive products color the water. Besides TNT, pink water usually contains cyclotrimethylene-trinitramine (RDX) and cyclotetramethylene-tetranitramine (HMX). The composition of pink water varies, depending on process materials and operations. The reference value established in this work is 200 parts per million (ppm) dissolved energetic-related materials.

Army ammunition plants meet discharge requirements by using GAC to remove contaminants from pink water. The explosives-laden GAC, classified as a K045 hazardous waste, is either regenerated for reuse or incinerated for disposal. Technologies are being sought to avoid the generation of this hazardous waste.

Concurrent Technologies Corporation (CTC), the operating contractor of the National Defense Center for Environmental Excellence (NDCEE), under the initial Statement of Work (SOW) from the U.S. Army Environmental Center (USAEC), was tasked to identify and evaluate the technologies as Phase I. This entailed surveying literature, assessing regulatory issues related to pink water, identifying candidate technologies, developing performance criteria and evaluation methods, selecting candidates for detailed evaluation, selecting the five best technologies based on the performance criteria and issuing a Phase I final report. The five technologies selected were Large Aquatic Plants (Biological) Treatment, GAC Thermophilic (Biological) Process, Fenton's Chemistry Process (Advanced Oxidation Process), Electrolytic Process (Mixed Oxidants) and Fluidized Bed Bioreactor Process.



Under Phase II, CTC was tasked to perform bench-scale tests on the five technologies using pink water generated from LAP operations at McAlester Army Ammunition Plant (MCAAP), Oklahoma, and pink water generated from demilitarization activities at Milan Army Ammunition Plant (MAAP), Tennessee. This entailed identifying vendors for the selected technologies, requesting test plans and safety plans from the vendors, determining critical process parameters and evaluation criteria, demonstrating and validating the bench-scale technologies, evaluating the technologies against the performance criteria, recommending the three best technologies for the pilot-scale demonstration and issuing a Phase II final report.

Under Phase III, CTC is tasked to plan for operation of up to three technologies at 2 gallons per minute (gpm). This entails developing detailed engineering specifications, submitting an outline of a test and implementation plan, submitting an outline of a demonstration and validation proposal, and issuing a Phase III final report.

USAEC has written an SOW to direct CTC to perform Phases IV through VI. Phase IV is the design, installation and debugging of the demonstration plant(s). Activities include selecting engineering design subcontractors, preparing detailed design estimates, finishing detailed designs, selecting ammunition plant demonstration location(s), fabricating the demonstration plant(s), and issuing a Phase IV final report. Phase V is operating and evaluating the demonstration plant(s). Activities include operating the plant(s) for 180 days, evaluating them according to the test plan and issuing a Phase V final report. Phase VI is finalization and follow-through. Activities include revising operating documentation based on lessons learned in the pilot-scale demonstration(s), providing follow-on training, and providing follow-through support.

ACCOMPLISHMENTS AND RESULTS

The Phase I literature search is complete, and a report has been submitted. Five technologies were selected for bench-scale testing. Phase II testing of the bench-scale technologies is complete, and CTC has submitted an approved Phase II final report. CTC submitted an approved program management plan/task plan for Phase III. USAEC approved an SOW for Phases IV through VI.

Other accomplishments include:

- Developed detailed designs for three pilot test plants.
- Selected MAAP for the full-scale demonstration.
- Fabricated the GAC Thermophilic (Biological) demonstration plant.
- Installed and debugged the GAC Thermophilic (Biological) demonstration plant.
- Completed five loadings and five regenerations of the GAC Thermophilic (Biological) demonstration plant (August 24, 1998 – October 30, 1998) with excellent removal of TNT.
- Performed Optimization studies of the GAC Thermophilic (Biological) demonstration plant for RDX removal.
- Completed the second cycle of six loadings and six regenerations (February 1, 1999 – April 29, 1999) with two of the demonstration tests



yielding an overall Dead Reckoning Error (DRE) greater than 99 percent, but one of the tests failed the toxicity evaluation criteria. The two best demonstration tests were repeated as Tests #12 and 13. The overall DRE were not as good this time, but adjusting the pH of the regenerant solution to normal after the alkaline hydrolysis eliminated the toxicity problem.

- Performed further optimization studies to the GAC Thermophilic (Biological) demonstration plant.
 - Currently conducting Demonstration Tests #14 through 16 based upon optimization studies using Sodium Succinate as the carbon source and pH control of the process.
-
- Conduct five demonstration tests of the best demonstration test (14 through 16) to verify that the GAC Thermophilic (Biological) demonstration plant can achieve greater than 90 percent DRE on every loading and regeneration cycle. This will ensure that the technology is successful and ready for transfer to full-scale implementation at various Army Ammunition Plants (AAPs).
 - Issue Phase V final report.
 - Technology Transfer of the GAC Thermophilic (Biological) demonstration plant to AAPs.

FOLLOW-ON PROGRAM REQUIREMENTS

POINT OF CONTACT

Louis Kanaras

PROGRAM PARTNERS

U.S. Army Environmental Center
Concurrent Technologies Corporation
National Defense Center for Environmental Excellence
McAlester Army Ammunition Plant, Oklahoma
Milan Army Ammunition Plant, Tennessee

PUBLICATIONS

Pink Water Treatment Options (May 1995).
Report No. SFIM-AEC-ETD-CR-95036.

Pink Water Treatment Options Technical Report (November 3, 1997).
Report No. SFIM-AEC-ET-CR-99064.

Safety/Health Plans to Build Thermophilic (Biological) Process Pilot Scale Equipment (June 22, 1998).

Test Plan for Thermophilic (Biological) Pilot-Scale Equipment (August 17, 1998).

Pilot-Scale Thermophilic (Biological) Process, Interim Test Results (December 22, 1998).

Pilot-Scale Thermophilic (Biological) Process, Results from 6th through 11th Loadings and Regeneration (May 21, 1999).

Pilot-Scale Thermophilic (Biological) Process, Results from 12th and 13th Loadings and Regeneration (July 21, 1999).



Pilot-Scale Thermophilic (Biological) Process, Results from 14th, 15th, and 16th Loadings and Regeneration, Draft (October 12, 1999).

◆ PLASMA ENERGY PYROLYSIS SYSTEM

The Army has identified various complex military waste streams that have significant costs associated with their disposal. Plasma arc technology can handle most of these waste streams in an efficient and cost-effective manner. The Plasma Energy Pyrolysis System (PEPS) project aims to build and improve on traditional plasma thermal technology.

PURPOSE

To build a continuously operating pre-production unit of a transportable PEPS.

BENEFITS

The PEPS program has focused on improvements to traditional plasma thermal technology and has realized a simple-to-control, automated operating system.

TECHNOLOGY USER

Department of Defense.

DESCRIPTION

The U.S. Army has identified various complex military waste streams that have significant costs associated with their disposal. Such waste streams require further treatment to mitigate their hazardous waste characteristics following treatment by conventional methods (e.g., heavy metals leaching out of incineration ash). Another problem with these complex military waste streams is that the current hazardous-waste treatment solutions are controversial with the public and the Environmental Protection Agency. These include open burning (with its associated uncontrolled emissions) or incineration of medical wastes (with its associated concerns regarding emissions of dioxin, furan and other carcinogens).

Plasma arc offers hope in solving many of these problems. In fiscal year 1997, Congress recommended \$7.5 million in funding for the U.S. Army Environmental Center as program director responsible for overall technical and fiscal management for this effort. The U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratories became the technical advisor for research and development of a cooperative project with the Tennessee Valley Authority to direct the acquisition, development, demonstration and validation of a PEPS in northern Virginia.

PEPS technology uses plasma arc torch energy in a reducing chamber to reduce – not combust – waste to a nonleachable glass slag and clean reusable gas. PEPS is a chemical reduction process, different from combustion (and without its byproducts). PEPS technology has been certified in California as an alternative to incineration for medical wastes, and in Washington state for low-level mixed wastes. The technology is flexible enough to run in reduction or combustion modes, can reform gas into a



pyrolysis product/fuel gas, possesses a smaller footprint than plasma-assisted incineration systems, and allows for continuous feeding.

Following successful demonstration, project deliverables will allow broader implementation.

ACCOMPLISHMENTS AND RESULTS

- Awarded a contract to Vanguard Research, Inc.
- Selected a private facility in Newington, Virginia, as a demonstration site.
- Identified medical waste and spent blast media as demonstration waste streams.
- Prepared and issued an Environmental Assessment (EA) and Finding of No Significant Impact (FONSI).
- Received approval of the EA and FONSI.
- Received approval of required permits.
- Completed site preparation activities.
- Built the PEPS system.
- Completed equipment inspection test.
- Completed spent blast media demonstration (9 to 19 August 1999).

LIMITATIONS

This technology costs more than conventional technologies and should find its niche in the "hard to treat" wastes.

FOLLOW-ON PROGRAM REQUIREMENTS

- Conduct a technology demonstration with medical waste.
- Produce the final technical report.
- Produce the final operations and maintenance manual.
- Produce the final cost and performance report.
- Complete deactivation and cleanup activities.

POINT OF CONTACT

Louis Kanaras

PROGRAM PARTNERS

U.S. Army Environmental Center
Tennessee Valley Authority
Vanguard Research, Inc.
Plasma Energy Applied Technology
U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratories



◆ ALTERNATIVE CLEANER PERFORMANCE VALIDATION

Many federal, state and local regulations limit the use, storage and disposal of hydrocarbon-based cleaning solvents – mainly because the solvents are considered toxic, flammable or hazardous. In addition, Executive Order 12856 requires a 50-percent reduction in the total release of toxic chemicals to the environment. Unfortunately, the Army and other defense agencies rely on these solvents to maintain unique, mission-critical systems and materiel.

PURPOSE

The situation presents the Army with various operational, environmental, financial, safety and regulatory challenges. To tackle these issues and reduce the hassles and expense of buying, storing and disposing of potentially harmful solvents, the Army has designed a program to dramatically increase the use of environmentally friendly products, such as enzymatic, aqueous-based and biodegradable cleaners where possible.

BENEFITS

This project is cutting through a wash of speculation and marketing claims by providing the Army a cost-effective mechanism to validate whether solvent alternatives meet tough mission standards – without harming the environment.

TECHNOLOGY USERS

Program, project and product managers throughout the acquisition community, and environmental staffs at major commands and installations.

DESCRIPTION

In 1998, more than 40 Army installations sought money for alternative cleaning systems through the Pollution Prevention Investment Fund. While these efforts show initiative and a commitment to stewardship, many installations have bought (or are trying to buy) products that haven't been fully qualified for use on Army equipment. In fact, some aqueous solvents may create rust or other problems in weapons and tactical vehicles. It's an easy mistake, since many products marketed to installations have a General Services Administration (GSA) contract number or an "environmentally friendly" listing in Defense Logistics Agency (DLA) catalogs. These designations aside, the Army itself must still prove whether these products meet military-specific performance requirements.

Building on past experience and lessons learned, the Army has launched a project that will allow manufacturers to validate the performance of alternative cleaning solvents on military equipment. Using a recent protocol developed in partnership with commodity managers, the U.S. Army Environmental Center and the U.S. Army Aberdeen Army Test Center lead a multi-agency initiative to comprehensively test several cleaning products and gather data the Army and other Department of Defense services can use to make procurement and usage decisions.

The agencies will use a thorough screening process to decide which products to put through the full range of performance tests. Testing will be jointly funded; solvent manufacturers will pay for the tests on their specific products, while the Army will maintain overall test capabilities and purchase materials needed to conduct the test.



Army commodity managers have agreed to disseminate joint technical bulletins regarding which solvent substitutes are approved for use once the project is completed. Approved solvent substitutes and systems will be eligible for funding.

ACCOMPLISHMENTS AND RESULTS

Thanks to the Alternative Solvents Substitutes Performance Validation Program, the Army will be able to better preserve readiness, save money and avoid bad decisions by knowing which alternative cleaning products meet its stringent requirements for performance, soldier safety and environmental compliance. Vendors and manufacturers will have an accepted process for validating their products for possible defense procurement.

POINT OF CONTACT

A.J. Walker

PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Aberdeen Test Center
U.S. Army Forces Command
U.S. Army Research Lab
U.S. Army Petroleum Center
U.S. Army Aviation and Missile Command
U.S. Army Armament, Development, and Engineering Center
U.S. Army Center for Health Promotion and Preventive Medicine
U.S. Army Tank Automotive and Armament Command
U.S. Army Tank Automotive Research and Development Center
U.S. Army Pollution Prevention Support Office
U.S. Army Integrated Product Teams
National Defense Center for Environmental Excellence
Naval Facilities Engineering Service Center
Naval Cognizant Field Activities
Naval Air Warfare Centers
Marine Corps Systems Command

**FLASHJET® COATINGS REMOVAL PROCESS**

The Defense Department is looking for alternatives to chemical paint removal and media blasting. The FLASHJET® coatings removal process, a xenon-flashlamp and frozen carbon dioxide combination patented by The Boeing Company, is a cost-effective and timesaving technology with potential military application.

PURPOSE

To demonstrate the FLASHJET® coatings removal process for military use.

BENEFITS

The FLASHJET® process offers low lifecycle costs, saves time and reduces the amount of hazardous waste generated during depainting.

TECHNOLOGY USERS

Department of Defense (DoD) depots and depot-level maintenance shops.



DESCRIPTION

Efforts are underway within DoD to find alternatives to chemical paint removal and media blasting. In the U.S. Army Environmental Requirements and Needs Report, requirements for finding alternatives to chemical paint removal and media blasting include Contaminated Blast Media (2.3.n); Hazardous Air Pollutant (HAP) Emission Control (2.1.g); and Alternate Paint Stripping Chemicals of Military Interest (3.2.h). The U.S. Navy requirements relating to depainting activities include Control/Reduce Emissions from Coating, Stripping and Cleaning Operations (2.1.1.g); Control of Volatile Organic Compound and HAP Emissions (2.1.1.q); and Non-hazardous Coating System Removal (3.1.5.a). U.S. Air Force depainting requirements include Substitute for Methylene Chloride Paint Strippers (449); Decreased Waste Generation from Plastic Media, Sand, Walnut Hull and Other Blasting Depaint Operations (808); and New Paint-Stripping Methods Have to Be Identified to Reduce Hazardous Waste and Cost (814). All of these requirements are considered high-ranking needs within their respective service.

As an environmentally preferred coatings-removal process, FLASHJET[®] eliminates the use of HAP chemicals and blasting media. The FLASHJET[®] process does not use any hazardous materials during the coating-removal stage, thus minimizing the potential for hazardous airborne dust and cutting the cost of paint removal.

FLASHJET[®] combines two depainting technologies in one process: a xenon-flashlamp and a continuous stream of recycled carbon dioxide pellets. The process also includes an effluent capture system that collects effluent ash and organic vapors. Effluent ash is captured by a series of high efficiency particulate air (HEPA) filters; organic vapors are processed through an activated charcoal tank. The process is fully automated and requires limited worker involvement.

The FLASHJET[®] system includes six components: the flashlamp and stripping head; the manipulator robotic arm; the computer processed cell controller; the effluent capture system; the carbon dioxide pelletizer; and the flashlamp power supply. The xenon-flashlamp is the primary coatings-removal step. The xenon-flashlamp emits low-pressure xenon gas and creates a high-intensity flash that ablates the coating from the surface. Light energy generated from the xenon-flashlamp pulses 4 to 6 times per second. The amount of coating ablated is directly proportional to the amount of energy put into the system. The process can be controlled to remove as little as .001 inches of coating and as much as .004 inches of coating. This control factor can be an asset when topcoat removal is required, but the underlying primer must remain on the substrate.

The carbon dioxide pellet-blasting technology is not a direct form of pellet blasting. The continuous stream of carbon dioxide pellets has two purposes. First, it cools and cleans the substrate, keeping the substrate at an acceptable temperature while the xenon-flashlamp ablates the coating. Second, the stream keeps the flashlamp clear of any coating by "pushing" the coating away from the flashlamp and toward the effluent capture system. All



carbon dioxide emitted during the process is captured from other industrial type sources, converted into liquid carbon dioxide and reused.

The effluent capture system collects all effluent ash and organic vapors generated during ablation. Effluent ash is vacuumed into the capture system, separated by size in a particle separator, and captured in a series of HEPA filters. Organic vapors are captured and processed through an activated charcoal scrub and emitted to the atmosphere with less than 10 parts per million light hydrocarbon emission.

The FLASHJET® process has several advantages over other commonly used depainting technologies. The only wastes generated are coating ash and spent HEPA filters. Compared to common media blasting and chemical paint-removal operations used at military depots, the FLASHJET® process has the potential to substantially reduce the amount of waste a facility generates.

The former McDonnell Douglas Corporation conducted lifecycle cost comparisons for the F/A-18A fighter aircraft. The estimated lifecycle cost for FLASHJET® was \$2.89 per square foot. Plastic media blasting was calculated at \$15.40 per square foot and chemical depainting was calculated at \$33.61 per square foot. Although the FLASHJET® process has a high acquisition cost, it is offset by an attractive lifecycle cost. These costs are calculated over a 15-year period.

The process is beginning to gain acceptance within DoD. The Air Force is on contract to install a system at the Warner-Robins Air Logistics Center in Georgia for stripping off-aircraft components. Corpus Christi Army Depot in Texas has installed a system for stripping the Army UH-60 Black Hawk and the Navy SH-60 Seahawk rotary wing aircraft, which should be operational before the end of fiscal year 2000. The FLASHJET® system installed at the Naval Air Station-Kingsville, Texas, for the Navy's T-45 program has operated since summer 1999. All three Naval Aviation Depots have a FLASHJET® system in their facility equipment plans.

ACCOMPLISHMENTS AND RESULTS

FLASHJET® has undergone eight years of extensive metallic and composite substrate panel testing for qualification purposes. The Navy approved the process for use on metallic fixed-wing aircraft, with composite fixed-wing aircraft approval expected before the end of calendar year 1999. After all the high-cycle fatigue tests are successfully completed for aluminum substrates, approval is expected from the services for metallic substrates on rotary-winged aircraft.

LIMITATIONS

The main limitation of the FLASHJET® process is its high acquisition cost. One system costs \$2.6 million, not including the expense of retrofitting an existing structure or constructing a new building. The system cannot access angles and tight corners due to the configuration of the stripping head; this could result in using more than one pass and increasing the xenon-flashlamp energy input, which could reduce the coating removal rate. The stripping head is approximately 15 inches long, including the xenon-flashlamp, the carbon



dioxide pellet stream nozzles, the containment shroud and the bump sensors. A secondary depainting process is needed for areas inaccessible to the stripping head. This problem, however, is commonly found with other depainting technologies. The Boeing Company is developing a smaller stripping head for removing coatings in hard-to-reach areas. One other limitation is that lighter colored paint is harder to strip than darker pigmented paint. Although not a large problem, it does require the operation pay closer attention to the process, especially during the initial set-up of the equipment.

**FOLLOW-ON PROGRAM
REQUIREMENTS**

Requirements for FY 2000 will concentrate on testing military vehicle and equipment demonstration, and the remaining high-cycle fatigue qualification testing. Vehicle and equipment demonstration will include stripping of the hull of M113 Armored Personnel Carrier. The demonstration on a flyable SH-60 Seahawk aircraft was postponed from last year until additional high-cycle fatigue tests could be completed, which occurred July 1999. The FLASHJET® SH-60 Aircraft demonstration began on October 13, 1999, and is scheduled for completion December 1999.

POINT OF CONTACT

Dean Hutchins

PROGRAM PARTNERS

U.S. Army Environmental Center
Department of Defense Environmental Security Technology Certification Program
Department of Defense program managers
Anniston Army Depot, Alabama
Corpus Christi Army Depot, Texas
Patuxent River Naval Air Station, Maryland
Naval Aviation Depot – Cherry Point, North Carolina
Warner-Robins Air Logistics Center, Georgia
Fort Hood, Texas
National Defense Center for Environmental Excellence
The Boeing Company

PUBLICATIONS

Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials. ASTM E466. 1997.

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Bonnar, G. R., and J.R. Hollinger. *Qualification of Xenon-Flashlamp/CO₂ Paint Removal Procedures for Use on Douglas Commercial Aircraft Components.* 93K0296. McDonnell Douglas Corp. for Douglas Aircraft Co. 1993.

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◆ HYDRAULIC FLUID RECYCLING

The Army employs hydraulic fluid when operating various types of equipment. Installations face disposal costs for used hydraulic fluid. By recycling hydraulic fluid to Army specifications, installations will reduce waste quantity and disposal charges.

PURPOSE

To reduce costs and increase readiness by implementing an affordable system to recycle used hydraulic fluid to Army specifications.

BENEFITS

Extending the life of fire resistant hydraulic fluid (FRH) saves money. Maintenance schedules would be easier to follow because procurement of FRH would decrease. The recycling systems' in-line monitors provide a simple means of determining FRH batch cleanliness, assuring maintenance personnel of the quality and readiness of the fluid. The machines are user-friendly, cost-effective and able to meet military needs.

TECHNOLOGY USERS

Army depots and Department of Defense facilities.

DESCRIPTION

Hydraulic fluid is disposed of as a hazardous waste. The military uses large quantities of FRH in a variety of materials from bridge launchers to forklifts. New FRH costs roughly \$10 per gallon. It costs less than \$3 to reclaim a gallon of FRH. Through recycling, the procurement needs and disposal volume of new fluid would be reduced 75 percent. Many installations could recoup the cost of their initial investment in the first year of reclamation.

Field demonstrations and analyses show that when mixed with 25 percent virgin material, recycled fluid meets all specification performance requirements. The demonstrations also show a need for real-time fluid analysis. To better meet the Army's needs, in-line sensors were used to determine the particulate and water content of the fluid being recycled.

FRH recycling began with research in the viability and field demonstration of commercially available recycling units.

Further analysis determined that some units produce FRH meeting military specifications. Cooperative Research and Development Agreements (CRADAs) were established to leverage government and private efforts to improve the design of the recyclers while increasing user-friendliness. In-line monitors were incorporated and tested for accuracy.



Installations can use a payback spreadsheet to determine the feasibility of using this technology.

ACCOMPLISHMENTS AND RESULTS

CRADAs were signed with Pall Aerospace and SESCO Inc. to add in-line sensors to their hydraulic fluid recyclers. The Pall Aerospace unit has been validated and is available for full-scale use.

The hydraulic fluid recycling draft report and final report of the monitoring unit test was submitted. A fact sheet was completed on hydraulic fluid recycling. Articles appeared in the *Environmental Update* and the *Army Logician*.

The unit is now field-ready and can be easily acquired.

LIMITATIONS

Hydraulic fluid recycling requires improved cleanliness, organization and used-fluid separation. The installation must make a commitment to good housekeeping. Burnt hydraulic fluid cannot be reclaimed.

FOLLOW-ON PROGRAM REQUIREMENTS

Technology transfer and implementation of the Pall system.

POINT OF CONTACT

Dennis Teefy

PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Tank-Automotive and Armaments Command Fuels and Lubricants Technology Team
Pall Aerospace
U.S. Army Aberdeen Test Center

PUBLICATIONS

Pall Hydraulic Fluid Recycling Unit with Automatic Cleanliness Monitoring System. CRADA Report.

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PROGRAM FOCUS
RANGE XXI



RANGE XXI: ACQUISITION INTERFACE

◆ GREEN AMMUNITION

Millions of small arms rounds are fired annually on military ranges during training and testing activities. These projectiles contain lead, a federally listed toxic material, and may pose an environmental risk to soil, sediments, surface water and groundwater. Replacing lead in conventional projectiles with a tungsten core will minimize environmental compliance impacts on training and help avoid costly cleanup efforts.

PURPOSE

To provide the Department of Defense (DoD) with small-caliber service ammunition that will meet U.S. and NATO performance standards while eliminating lead in the projectile core.

BENEFITS

This program will revolutionize small-caliber ammunition. The next generation of ammunition, while benign to the environment, potentially offers enhanced lethality and functionality. Environmental restrictions on training U.S. military personnel will be minimized. Training realism and effectiveness will be greatly enhanced, while future cleanup costs may be eliminated. Furthermore, DoD will be the international leader in these technologies, and the environmental stewardship shown will enhance both public image and trust.

TECHNOLOGY USERS

U.S. Army Armament Research, Development and Engineering Center (ARDEC), Small Caliber Ammo Branch
U.S. Army Infantry Center
U.S. Army Research Laboratory
Naval Surface Warfare Center-Crane (NSWC)
Department of Energy (DOE) Oak Ridge National Laboratory (ORNL)

DESCRIPTION

Lead in soil, sediment, surface water and groundwater has been confirmed through investigations at Army, Navy, Marine Corps and Air Force small arms ranges throughout the United States and Europe. Lead uptake studies in vegetation at a Marine Corps range in Quantico, Virginia, showed lead levels as high as 23,200 parts per million. Remediation has proven to be extremely expensive. Furthermore, inspections of National Guard indoor ranges from 1986 to 1988 resulted in 812 ranges being shut down due to high levels of lead contamination, both surface and airborne. Those ranges will require costly renovations to meet Environmental Protection Agency and Occupational Safety and Health Administration standards.

About 689 million rounds of small arms ammunition (.22-caliber through .50-caliber) are fired annually during DoD training, with an additional 10 million rounds fired annually by DOE. The annual amount of heavy metal introduced into the environment from this training is approximately 3 million pounds.

The lead projectile cores and compounds used in primers create dust and fumes when fired, exposing shooters and range operators to dangerously high levels of airborne lead. Studies from the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) show that projectiles account for 80 percent of airborne lead released on firing ranges, while the



remaining 20 percent comes from primer combustion. The studies also indicate that 40 percent of inhaled lead is dissolved in the bloodstream, and 10 percent is absorbed directly by the body. Once in the body, lead is very difficult to remove.

The Joint Service Non-Toxic Ammunition Working Group was established in 1995 by ARDEC as a multiservice cooperative forum of DoD, DOE, private industry and academia experts. ARDEC is responsible for overall program management and execution.

The U.S. Army Environmental Center (USAEC) has funded efforts to eliminate lead from the projectile core. This focus is due to the lead buildup from rounds in small arms range impact areas, which could result in noncompliance with environmental laws and regulations.

The next generation of small arms projectiles will rely on innovative materials to reproduce and improve upon the physical, ballistic and mechanical properties of lead. Composite materials, such as metal powders in nylon or high-density metal particulates bonded with light metals, are being examined as nontoxic replacements for lead.

Concurrent with the USAEC-funded demonstration of an alternative 5.56-mm projectile, other efforts will target the toxic components in the cartridge primer and manufacturing process.

Of primary concern at outdoor ranges is the introduction and dispersion of tungsten throughout the environment. Development of the toxicity and environmental recovery information to support recycling or closed-loop use of the materials, and data on environmental effects, is being determined. Additional leaching, environmental corrosion and biological uptake tests will be performed to fully define stability and mobility characteristics. Study results will guide projectile formulation such that all materials will be stable and recoverable. Projectile design, constituent materials and processing will be optimized to support the maximum recovery and recyclability of this next generation of projectile materials. USAEC will specify recovery and recycle methods and provide for the pilot-scale demonstration. Adequate information regarding the use, release and mobility of the high-density constituents under consideration, specifically tungsten, is considered crucial for acceptance.

Demonstrating the producibility of the lead-free projectile is as critical as the performance demonstrations. If the items cannot be produced in a cost-effective, environmentally compliant fashion, the technology will fail. Lake City Army Ammunition Plant (LCAAP) in Missouri is the Army's principal supplier of small-caliber ammunition. The producibility testing of the proposed nontoxic projectile will be performed at LCAAP. Additionally, other environmental issues regarding production methods, machinery and support materials for small-caliber ammunition manufacture will be addressed.



Producibility testing will be used to minimize production costs and provide feedback to the projectile and primer designers. Production rates of 1,200 items per minute require special consideration in item design and manufacture. Performing producibility tests will assure that item unit-costs stay within 10 percent of current ammunition production costs.

USAEC plans to provide funding for qualification tests and type classification of the new 5.56-mm cartridge for Armywide implementation. At the start of Phase II, the composite materials identified in Phase I will be refined. Approximately 100,000 rounds of the successful candidates from Phase I (i.e., tungsten/nylon and tungsten/tin) will be purchased from Texas Research Institute and Powell River Laboratories, Inc. A task order contract will be prepared for LCAAP to assemble and load M855 cartridges using the composite projectiles. Cartridges from each lot will be subjected to standard production verification testing to ensure their safety and performance. All cartridges will then be shipped to the NSWC in Crane, Indiana, for qualification testing.

Qualification test requirements and ammunition quantities will be finalized. Tests not conducted during Phase I that have the highest likelihood of revealing projectile-related deficiencies will be conducted first. Some of these tests will include environmental conditioning (hot and cold temperature cycling), rough handling, and barrel erosion. These tests will narrow the selection to one material. The remainder of the testing will include, but not be limited to, electronic pressure, velocity and action time, dispersion and penetration. If both candidates meet all requirements, both will be considered qualified alternate materials.

During Phase III, the technology will be transitioned to the 7.62-mm and the 9-mm projectiles, and demonstration/testing of those configurations will be performed. Concurrent with the manufacture and testing activities, a corrosion and lifecycle cost analysis will be performed for all three calibers. This effort will examine product cost from raw material processing through manufacture, use and eventual disposal or recycling.

ACCOMPLISHMENTS AND RESULTS

During Phase I, USAEC and ARDEC demonstrated the viability of seven nondevelopmental item formulations to replace lead in the 5.56-mm projectiles. Composite materials tested during Phase I consisted of tungsten bonded with light metals (i.e., tin and zinc) or synthetics (i.e., nylon). Composites were subjected to a high-speed assembly and loading process to produce net shape cores with physical properties similar to lead. Projectiles underwent ballistics performance testing for dispersion, penetration, electronic pressure, velocity and action time. Phase I isolated two candidates suitable for replacing the current 5.56-mm service round. Toxicity studies on tungsten are being analyzed at ORNL and USACHPPM.

The final report of the demonstration of lead-free alternatives for 5.56-mm ammunition was submitted to USAEC in February 1997. Both configurations advanced through Phase II to production.



**FOLLOW-ON PROGRAM
REQUIREMENTS**

- Complete Phase II (select final candidates).
- Complete Phase III (transition the technology to other calibers).

POINTS OF CONTACT

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PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Armament Research, Development and Engineering Center
Lake City Army Ammunition Plant, Missouri
Oak Ridge National Laboratory
Naval Surface Warfare Center, Crane, Indiana
Naval Surface Warfare Center, Indian Head, Maryland



RANGE XXI: IMPACT AREA EVALUATION



UXO DEGRADATION IMPACT ANALYSIS

PURPOSE

To provide the U.S. Army with a tool to assess the potential time of corrosion to perforation of unexploded ordnance (UXO).

BENEFITS

This program will enable installation range managers to evaluate the potential risk from UXO on their installations. This tool can be used as a program management aid to evaluate risk of perforation of UXO and the spilling of contaminants into the environment. Environmental restrictions on training U.S. military personnel will be minimized. Future cleanup costs may be reduced. Furthermore, the environmental stewardship observed will enhance both public image and trust.

TECHNOLOGY USERS

U.S. Army Installations
U.S. Army Research Laboratory (ARL)
U.S. Army Corps of Engineers – Waterways Experiment Station

DESCRIPTION

Testing and training operations using exploding ordnance continue to play a key role in maintaining the readiness of the warfighter. A portion of the rounds used in these operations malfunctions, resulting in UXO. UXO exists at impact areas on the surface and buried in soil, in wetlands sediment and in water, under both aerobic and anoxic conditions. Data on the condition of existing UXO and its impacts on the environment has not been collected or evaluated. Additionally, factors that may affect the condition of UXO (such as munition type, soil type, aqueous conditions and pH) have not been evaluated. This study is an evaluation of the potential corrosion of UXO.

The Army has a growing need to respond to regulatory questions about the environmental impact of UXO in and around firing ranges. As a result, the U.S. Army Aberdeen Test Center (ATC), under the direction of the U.S. Army Environmental Center (USAEC), has established a program to address these issues. The data to be gathered for this program provides information on the likelihood of UXO to degrade to the point of environmental air, soil and groundwater contamination. Models predicting the environmental conditions that affect UXO degradation will be investigated. This data will support, define and, if necessary, modify future Army training/testing practices.

The power of using modeling and simulation resides in the ability to quickly perform many iterations of a basic scheme to predict results. As related to environmental sciences, modeling enables scientists to predict long-term manifestations of the effects of stresses to the environment. This paper discusses how modeling and simulation determine if and how unexploded conventional ordnance on military test ranges degrades over time, and identifies the potential fate and migrations of the by-products. This report presents the parameters, assumptions and constraints of the modeling techniques being used in the development of this model.

The modeling process will involve using several ranges at the Aberdeen Proving Ground (APG), Maryland, as test beds. Data from the various ranges



will be used to develop one or more statistical soil types. Corrosion modeling based on soil type, and the associated leaching of any by-products of this process into this soil, will be performed using techniques under development at the ARL Weapons and Materials Research Directorate. The results will aid in the development of risk assessments.

A phased approach has been developed. Phase I encompassed an extensive data search, data evaluation, development of test methodology, objectives and data quality standards. The focus of this effort was to perform an extensive data search, evaluate the available data for adequacy, quantitatively analyze the data, and, if necessary, perform limited soil and groundwater sampling and analysis and document findings.

The data generated will support the U.S. Army and U.S. Army installations in assessing the environmental impact of weapons firing as a part of testing and training operations.

Furthermore, assessments can be performed with fate and transport work. Should perforation occur, the effects can be determined and monitored.

ACCOMPLISHMENTS AND RESULTS

During Phase I, USAEC and ATC developed a low fidelity model. Phase II produced a model with more real world data. Approximately 20 samples were collected to refine the model and ensure its accuracy. Currently, the model is considered 90 percent accurate for approximately 30 to 50 years.

The final report for Phases I and II will be finalized prior to the end of calendar year 2000. Along with the report will be a Corrosion Model and user's manual. These tools can be used by installation range managers to assess the time to perforation on their ranges to determine if a potential for breakthrough exists.

FOLLOW-ON-PROGRAM REQUIREMENTS

Complete Phase II, including the following steps:

1. Perform literature searches of all pertinent databases for existing data on impact areas and the condition of munitions.
2. Conduct interviews with Research, Development, Test, and Evaluation, industry and environmental personnel to take maximum advantage of work previously completed. Search areas shall include, but not be limited to:
 - Base Realignment and Closure databases and reports
 - Studies at the Marine Corps Air Ground Combat Center at 29 Palms
 - Studies at Ft. Meade, Maryland
 - APG Range Study
 - Studies at Camp Grayling
 - Studies at Grafn Vhor, Germany
 - Data on the excavation of the Superpond at APG, and data from other Major Range and Test Facility Bases.



POINT OF CONTACT

Tamera Clark

PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Aberdeen Test Center
Louisiana State University
Logicon



UXO TECHNOLOGY DEMONSTRATION PROGRAM

The Department of Defense needs advanced methods to detect, locate, identify, neutralize, recover and dispose of unexploded ordnance (UXO). The UXO Technology Demonstration Program, conducted at Jefferson Proving Ground, Indiana, has established a framework to better understand and assess UXO technologies.

PURPOSE

To evaluate, establish and advance UXO technology performance.

BENEFITS

This program has created a framework for the evaluation of UXO technology. Baseline technology performance has been established, and technology capabilities and limitations have been assessed. Technology users are better able to select the optimum technology or system for their needs. Private industry has benefited from program feedback, and participants are better able to improve their systems.

TECHNOLOGY USERS

Military installations with sites that contain UXO.

DESCRIPTION

Congress mandated the UXO Technology Demonstration Program. More than 60 technology demonstrations of UXO characterization and remediation technologies were conducted. Phase I, Phase II and Phase III were conducted in 1994, 1995 and 1996 at Jefferson Proving Ground, Indiana. The demonstrations were performed on a controlled test site containing a known baseline of emplaced, inert ordnance. Additional technology demonstrations were conducted during 1995 at five U.S. sites that contained live ordnance.

For each phase of the demonstration program, companies and government agencies were given the opportunity to demonstrate their system capabilities. Details of the multiphase demonstration programs were published in reports.

Results of the most recent Phase III demonstrations show that overall technology detection rates have improved since the initial Phase I demonstration program in 1994. Phase III results show that state-of-the-art technology can detect a substantial portion of emplaced ordnance (over 95 percent). However, significant technology limitations exist. There has been no substantial change in the ability of demonstrators to discriminate UXO from non-UXO material (known as "clutter"). This deficiency is a major cost driver in UXO characterization due to additional data analysis requirements and subsequent unnecessary excavation. Remote excavation of UXO is feasible;



the systems were able to locate, excavate and handle the UXO. However, they were slow and inefficient.

The Phase IV effort underway capitalized on previous UXO technological investments by focusing on target discrimination and reduction of false-alarm rates. This effort provided the government with state-of-the-art technology for target discrimination capabilities.

ACCOMPLISHMENTS AND RESULTS

Results from this program have been used across the U.S. to aid in the selection and utilization of companies, systems and sensors for UXO characterization and restoration efforts.

- Technology enhancements.
- Technology demonstrations.
- Evaluation and reporting.
- Technology transfer.
- Identification of support to continue demonstration activities.

POINT OF CONTACT

George Robitaille

PROGRAM PARTNERS

U.S. Army Environmental Center
Naval Explosive Ordnance Disposal Technology Division
U.S. Army Corps of Engineers

PUBLICATIONS

Unexploded Ordnance Advanced Technology Demonstration Program at Jefferson Proving Ground (Phase I). December 1994.

Evaluation of Individual Demonstrator Performance at the Unexploded Ordnance Advanced Technology Demonstration Program at Jefferson Proving Ground (Phase I). March 1995.

Unexploded Ordnance Advanced Technology Demonstration Program at Jefferson Proving Ground (Phase II). June 1996.

Live Site Unexploded Ordnance Advanced Technology Demonstration Program. June 1996.

Unexploded Ordnance Technology Demonstration Program at Jefferson Proving Ground (Phase III). April 1997.

The Phase IV Report will be available on the USAEC Web site.



RANGE XXI: SMALL ARMS RANGE TECHNOLOGY

◆ SHOCK-ABSORBING CONCRETE PERFORMANCE AND RECYCLING DEMONSTRATION

Recovering lead and other bullet fragments from conventional soil berms is often difficult. As a result, lead and other heavy metals may leach into groundwater, potentially resulting in a remediation effort. Bullet traps constructed from shock-absorbing concrete will retain bullets while providing an easy-to-recycle berm material.

PURPOSE

To assess the use of Shock-Absorbing Concrete (SACON) to reduce the potential of offsite migration of lead and other heavy metals.

BENEFITS

SACON may provide a means to recycle projectiles and prevent buildup of heavy metals in range soils. SACON could also mitigate the excessive soil erosion experienced on outdoor ranges caused by bullet impacts. Erosion control and soil stabilization would help prevent migration of heavy metals off the range, and alleviate the recurring costs of land rehabilitation on the ranges. In addition, SACON may reduce or eliminate safety problems caused by ricochets off natural or other materials.

TECHNOLOGY USERS

The Army – primarily Forces Command and Training and Doctrine Command installations – as well as the National Guard, Navy, Marine Corps, Air Force and Coast Guard.

DESCRIPTION

Numerous Department of Defense small arms ranges contain lead and other metals in soils. In some cases, those inorganic materials may “migrate” to surface water or groundwater. The Army operates approximately 1,400 outdoor small arms ranges in the continental United States; the Navy runs approximately 270 outdoor small arms ranges (including Marine ranges), and the Air Force operates approximately 200 outdoor small arms ranges. The U.S. Army Environmental Center (USAEC), U.S. Army Training Support Center and U.S. Army Engineer Research and Development Center-Waterways Experiment Station seek ways to reduce the potential of offsite migration of lead and other heavy metals.

SACON has been used as a bullet-stopping material since the 1980s. It has been extensively field tested with a variety of small arms, including military and civilian automatic and semi-automatic weapons. The Army and other federal and state agencies have fabricated “training villages” from SACON. However, SACON has not been demonstrated as a berm material on conventional small arms ranges.

SACON can be used to build safe, durable, low-maintenance barriers that can hold spent bullets in a low-permeability, alkaline matrix that will minimize escape of potentially harmful metals into surrounding soil or groundwater. After use, the SACON bullet traps can be recycled. The SACON is crushed and the bullet fragments separated from the crushed material. The aggregate developed from the crushed SACON can be used to recast blocks in a new foamed concrete mixture. The bullet fragments can be recycled.



Demonstration objectives focused on identifying and validating the performance, cost, safety, logistics, training realism and recycling aspects of the SACON bullet trap material. Field demonstration of SACON was conducted at the United States Military Academy in West Point, New York, from April through November 1997 and at Fort Knox, Kentucky, from March 1997 through January 1998. SACON recycling was demonstrated at Engineer Research and Development Center (ERDC), Vicksburg Pvt, in October 1997. Accelerated durability and ricochet testing was conducted at U.S. Army Aberdeen Test Center (ATC) in March 1998.

ACCOMPLISHMENTS AND RESULTS

Field demonstrations were completed in March 1998. A final technical report was issued in August 1999, and a draft cost and performance report is under review. A summary of performance results follows:

SACON does provide range managers with a means of effectively capturing and containing lead on small arms ranges. SACON offers significant benefits in comparison to current Commercial Off-The-Shelf (COTS) technologies. It exhibits an ability to inhibit the leaching of lead corrosion products. Other COTS bullet traps and soil berms lack this lead stabilization capability. The waste generated from the use of SACON is not classified as a hazardous waste and can be disposed of as a solid waste. SACON is not flammable and can be formed in any shape, making it adaptable to more range applications than standard COTS technologies. However, like all bullet traps, SACON is an expensive means of mitigating the risk of lead transport from ranges and should be considered only as a last resort for keeping ranges environmentally compliant. Other methods of reducing lead transport risk should be investigated prior to installing any bullet trap technology. New methods of stabilizing the lead on the range and mitigating physical lead transport in storm water runoff are being developed and may provide more cost-effective means of reducing lead transport risk and bioavailability.

LIMITATIONS

Use of SACON to capture rounds may result in:

- Increased maintenance costs for ranges;
- Increased construction costs for new or refurbished ranges;
- Reduced range use flexibility (SACON must be designed for specific calibers of ammunition).

FOLLOW-ON PROGRAM REQUIREMENTS

- Complete the Cost and Performance Report
- Complete the Construction Report (User's Guide).
- Disseminate the demonstration results through USAEC's Web site and articles.

POINT OF CONTACT

Gene Fabian

PROGRAM PARTNERS

U.S. Army Environmental Center
 Combat Training Support Directorate, Deputy Chief of Staff-Training, Training and Doctrine Command
 U.S. Army Engineer Research and Development Center-Waterways Experiment Station



U.S. Military Academy, New York
Fort Knox, Kentucky
Environmental Security Technology Certification Program
U.S. Army Aberdeen Test Center

PUBLICATIONS

“Management of Spent Bullets and Bullet Debris on Training Ranges.”
Presentation for the American Defense Preparedness Association (ADPA)
1997 Waste Management Conference.

“Chemical Containment of Heavy Metals from Bullet Debris in Shock-Absorbing Concrete (SACON) Bullet Barriers.” Paper presented at the 23rd ADPA Environmental Symposium.

“Design of Modular Bullet Trapping Units Using Shock-Absorbing Concrete (SACON).” Paper presented at the 1997 Tri-Service Environmental Workshop.

Final Report, Demonstration of Shock-Absorbing Concrete (SACON) Bullet Trap Technology, USAEC Report No. SFIM-AEC-ET-CR-99017, August 1999.



SMALL ARMS RANGE BULLET TRAP DEMONSTRATIONS

Lead from bullets fired on small arms ranges may contaminate groundwater and soil. Such lead contamination could lead to range closure and long-term cleanup costs. Capturing the bullets will prevent the lead from entering the environment. The use of bullet traps on small arms ranges may prevent pollution and result in greater range availability for training and environmental protection.

PURPOSE

To reduce the potential of offsite migration of lead and other heavy metals; to reduce the impacts on the environment; and to promote training readiness through pollution prevention methods that reduce environmental compliance impacts.

BENEFITS

Bullet traps may provide a means to recycle projectiles and prevent contamination of ranges and the surrounding environment. Bullet traps would also mitigate excessive soil erosion on outdoor ranges caused by the impact of the projectiles. Erosion control and soil stabilization on the ranges would help prevent the off-range migration of heavy-metal contaminants.

TECHNOLOGY USERS

Army and Department of Defense installations with small arms ranges. There may also be civilian applications.

DESCRIPTION

The Army operates approximately 1,400 outdoor small arms ranges in the continental United States; the Navy runs approximately 270 outdoor small arms ranges (including Marine ranges), and the Air Force operates approximately 200 outdoor small arms ranges.



Future regulatory focus may restrict testing and training activities and force the closure of valuable small arms range facilities unless methods are implemented to capture and recycle projectile material and prevent contamination of the range and the surrounding environment. Bullets from small arms are primarily lead, listed as a toxic material under the federal Resource Conservation and Recovery Act (RCRA). Once in soil, bullets may corrode and the lead may enter groundwater or surface water, resulting in a potential violation of RCRA or other laws. Cleanup of water contaminated with lead is costly, and contamination may result in range closures or restricted use.

Bullet traps can reduce the amount of lead and other metal compounds that end up in soil. Use of bullet traps is presently limited to only a handful of military installations and primarily confined to indoor ranges. This project assesses the performance capabilities of three commercially available bullet traps for use at outdoor military ranges.

Techniques that limit the volume of soil containing heavy metals at small arms ranges also will limit cleanup costs and prevent regulatory restrictions of testing and training activities at active sites. Bullet traps that capture and contain projectiles for recycling will limit or possibly prevent soil contamination on training sites.

ACCOMPLISHMENTS AND RESULTS

Accelerated testing was completed on three commercially available bullet traps. The following types of traps were tested in a 25-meter range backstop scenario: composite rubber block trap; granular (or shredded) rubber trap; and steel decelerator-type trap.

The consensus is that the bullet traps do not meet their manufacturers' performance claims. Problems ranged from ill-defined usage limitations to lead-dust containment and exposure concerns. A report documenting the traps' performance, environmental benefits and cost analyses will be available.

LIMITATIONS

Use of bullet traps to capture lead may result in:

- Increased maintenance costs for ranges;
- Increased construction costs for new or refurbished ranges;
- Reduced training realism (in some cases);
- Reduced range use flexibility (some bullets or weapons might damage the traps);
- Increased environmental and personnel exposure risks (if the selected trap is not suited for the type of ammunition used on the range).

FOLLOW-ON PROGRAM REQUIREMENTS

Complete the bullet trap demonstration report and publicize the demonstration results through the U.S. Army Environmental Center's Web site and articles.

POINT OF CONTACT

Gene Fabian



PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Training Support Center
U.S. Army Aberdeen Test Center

PUBLICATIONS

Final Report, Bullet Trap Feasibility Assessment and Implementation Plan, Technology Identification Report. Report Number SFIM-AEC-ET-CR-96005. March 1996.

Final Report, Bullet Trap Feasibility Assessment and Implementation Plan, Evaluation Criteria Report. Report Number SFIM-AEC-ET-CR-96142. April 1996.

Final Report, Bullet Trap Feasibility Assessment. Report Number SFIM-AEC-ET-CR-96195. December 1996.

Final Report, Bullet Trap User's Guide. Report Number SFIM-AEC-ET-CR-96201. December 1996.



◆ DUST CONTROL GUIDANCE AND TECHNOLOGY SELECTION KEY

Military activities generate dust that constrains training, impedes the mission, creates safety problems, damages equipment, contributes to soil erosion, and may violate environmental laws such as the Clean Air Act. The technology to help installations curb this problem exists, but guidance on the identification, selection and application of installation-specific dust control measures has been difficult to find.

PURPOSE	To assist Army installation land managers in identifying, selecting and applying the best tools, techniques and products for dust control on tank trails, roads, landing strips and helipads.
BENEFITS	Users can take the selection key brochure to the field and sort their options as they assess a site's conditions. The key matches site information – such as climate, soil type, surface characteristics, and the types and number of vehicles that use it –with appropriate and cost-effective dust control strategies.
TECHNOLOGY USERS	Army installation land managers.
DESCRIPTION	<p>The <i>Dust Control Guidance and Technology Selection Key</i> comes in two compatible formats: a brochure and an interactive computer program. The Web-based computer program includes a comprehensive handbook that users can consult for answers to questions that surface while in the field.</p> <p>The handbook includes ways to identify areas that need dust control, as well as explanations of site maintenance, construction methods and mechanical stabilization practices to consider before using dust control products. It also provides references pertaining to dust control programs used by other federal and state agencies, and a flow chart for quick reference.</p>
ACCOMPLISHMENTS AND RESULTS	The selection key was field-demonstrated at Forts Pickett, Stewart and Leonard Wood, and the Orchard Training Area in Idaho. The demonstrations were completed in November 1998.
LIMITATIONS	The key is specifically designed for controlling dust on roadways, trails and aircraft landing zones. This document is not all-inclusive. The U.S. Army Environmental Center (USAEC) does not endorse any commercial products listed in the document.
FOLLOW-ON PROGRAM REQUIREMENTS	Demonstration comments were incorporated into the selection key. The major commands suggested including wheeled and tracked vehicle testing of each product type in the document; this inclusion will depend on available funding. This program was completed in fiscal year 1999.
POINT OF CONTACT	Kim Michaels



PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Engineering Research and Development Center
U.S. Army Training and Doctrine Command
U.S. Army Forces Command
National Guard Bureau
Fort Pickett, Virginia
Fort Stewart, Georgia
Fort Leonard Wood, Missouri
Orchard Training Area, Idaho

PUBLICATIONS

The final guidance document is available through the USAEC Technical Information Center at the following address: USAECTIC@aec.apgea.army.mil.

**LAND-BASED CARRYING CAPACITY**

The Army's primary missions are to train soldiers and test weapons and defense systems. Trainers and land managers realize that training and testing areas must be realistic, ecologically healthy and ready for long-term use. Land-Based Carrying Capacity (LBCC) technologies will help installations estimate current and predict future land-condition status, and establish a relationship between training load and land condition.

PURPOSE

To demonstrate and validate four products that apply directly to the improvement of the environmental component of the Army Training and Testing Area Carrying Capacity (ATTACC) model. These products could also serve as stand-alone tools for natural resources and land management activities.

BENEFITS

LBCC technologies will help installations estimate current and predict future land-condition status, and establish a relationship between training load and land condition.

TECHNOLOGY USERS

Army trainers, land managers and natural resource managers.

DESCRIPTION

Installation land and natural resource managers need efficient tools, models and techniques to characterize, integrate constraints on, and quantify the capability of land and natural resources to support military training and testing missions. Installation training managers need to identify carrying capacity of training lands, predict the impacts of land-based usage, understand risk associated with use, and analyze decisions to provide training flexibility versus environmental or ecological damage.

The cover factor (C Factor), improved slope length and steepness factor (LS Factor) and distribution modeling demonstration validation studies will be conducted at Fort Hood, Texas. The Community Dynamics Simulation (EDYS) demonstration validation effort will be conducted at Fort Bliss, Texas, and Fort Hood.



Four products will be demonstrated and validated:

- Improvement to the Revised Universal Soil Loss Equation (RUSLE), specifically an LS Factor based on the unit stream power theory and upslope contributing area;
- Improvement to the RUSLE, specifically the use of a vegetation-index-derived method for extrapolating the C Factor measured at Land Condition Trend Analysis sites;
- An EDYS model that predicts changes in plant species composition over time and in response to natural and anthropogenic disturbances;
- A training distribution map that utilizes spatial terrain characteristics to predict the pattern and intensity of the training load over the landscape.

ACCOMPLISHMENTS AND RESULTS

Fort Hood, Fort Bliss, the U.S. Army Environmental Center and the U.S. Army Engineering Research and Development Center met to plan the project. The project was well received and was implemented successfully at both demonstration installations.

LIMITATIONS

The four products must be approved individually by the ATTACC governing body. It should not be automatically assumed that these products will be incorporated into ATTACC until authorization is given.

FOLLOW-ON PROGRAM REQUIREMENTS

This project covers only the first phase of the EDYS demonstration.

POINT OF CONTACT

Kim Michaels

PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Engineering Research and Development Center
Fort Hood, Texas
Fort Bliss, Texas
U.S. Army Training and Doctrine Command
U.S. Army Forces Command
U.S. Army Training Support Center

**TACTICAL CONCEALMENT AREA PLANNING AND DESIGN GUIDANCE DOCUMENT**

Installation trainers and environmental resource managers need tools to help them combat the problems of training-site degradation and rehabilitation. The U.S. Army Environmental Center (USAEC) and U.S. Army Engineering Research and Development Center have developed a planning and design tool to help trainers and land managers enhance installation training resources using suitable development techniques for improving wildlife habitat, environmental-resource protection and soldier safety.



PURPOSE

To demonstrate the applicability, usefulness and viability of an installation-based Tactical Concealment Area (TCA) guidance document.

BENEFITS

The project will produce an approach to training land design that realizes a systematic integration of training and environmental requirements to enhance and expand an installation's training resources. The technology will help create realistic training areas, protect natural and cultural resources, and enhance environmental stability. This document will give installations the opportunity to create and integrate tactical concealment into total training area design. The document will also provide guidance that allows the installation to complete work in-house rather than by contract.

TECHNOLOGY USERS

Army trainers, and installation natural and cultural resources managers.

DESCRIPTION

The development and use of well-designed tactical concealment enhances training realism and effectiveness by providing cover in a tactical training environment. The added benefit of isolating potentially hazardous areas and protecting sensitive areas from training activities suggests that tactical concealment needs to be carefully designed and integrated into the total training area design and the environment to optimize effectiveness and overall environmental stability.

The first U.S. tactical concealment design was implemented at Fort Riley, Kansas. The design was constructed as a cluster of horseshoe-shaped islands. Subsequent tactical concealment areas at other installations followed the Fort Riley design with slight modifications. Recent observations of the design's military use indicate flaws; efforts are underway to evaluate these flaws and eliminate them from planning and design of new TCAs.

The TCA guidance document takes holistic approach that considers an installation's training needs, existing resources and environmental constraints in planning and designing realistic training areas. The result is greater safety, less equipment damage, fewer environmental impacts, and enhanced training realism. The TCA guidance document details how to integrate both training and environmental considerations into the planning process and how to effectively implement the design. The guidance document gives installations the opportunity to complete work in-house, saving money and affording installations more control over their projects.

ACCOMPLISHMENTS AND RESULTS

The TCA guidance document was field-tested at several demonstration sites: Camp Bullis, Texas; Fort Hood, Texas; Camp Guernsey, Wyoming; and Camp Ripley, Minnesota. The demonstrations proved the utility and applicability of the guidance document at Army installations. Direct user input from the demonstration sites (as well as comments from other installations and major commands) has been integrated into the document.

This project was well received when briefed at the fiscal year 1996 Army Integrated Training Area Management (ITAM) Workshop and the fiscal year



1997 National Guard ITAM Workshop. Two National Guard sites – Camp Guernsey and Camp Ripley – joined the project in June 1997. Demonstration results were briefed at both FY 1998 ITAM workshops.

This program was completed in FY 1999.

This document is not a complete answer to solving all training area management problems; it is a guide for installations that need assistance.

FOLLOW-ON PROGRAM REQUIREMENTS

Installation monitoring will take place past the “project complete” stage. It may be necessary for installations to complete site modifications to better service their training missions.

POINT OF CONTACT

Kim Michaels

PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Engineering Research and Development Center
U.S. Army Training Support Center
U.S. Army Training and Doctrine Command
U.S. Army Forces Command
National Guard Bureau
Fort Hood, Texas
Camp Bullis, Texas
Camp Guernsey, Wyoming
Camp Ripley, Minnesota

PUBLICATIONS

The final guidance document is available through the USAEC Technical Information Center at the following address: USAECTIC@aec.apgea.army.mil.



VEGETATION WEAR TOLERANCE

Erosion can affect the quality of training sites and the environment on Army installations. Revegetating eroded areas with species able to tolerate heavy vehicle and troop traffic will reduce erosion, keep lands open for training and maneuvers and save time and money.

PURPOSE

To determine which vegetative species are the most tolerant to wear from troop and vehicle traffic on individual installations within a climatic region.

BENEFITS

Revegetating eroded areas with species able to tolerate heavy vehicle and troop traffic will reduce erosion, keep lands open to training and maneuvers and save time and funds.

TECHNOLOGY USERS

Installation range and natural resource managers.



DESCRIPTION

Demonstrations using vegetation thought to best reclaim eroding land and withstand wear from troops and vehicles will be conducted at three installations within a regional climatic area, on two or three dominant soil types.

After selecting the region and installation for the initial demonstration, researchers will select best-known species for use by installation and climatic region (including soils). They will design a test and demonstration project that can be used at all sites for statistical analysis and evaluation. They will then select specific sites on the installations and begin the demonstration.

Researchers will monitor the demonstrations for three to four years. The demonstrations will involve controlled troop and vehicle traffic, submitting the plants to diverse levels of wear. Based on the test results, certain species will be recommended for installation and regional use. The species may be installation-specific to one or more soils, or may be adaptable to all installations and soils within the climatic region. Information on these species will be available on the VegSpec computer program, so natural resource and range managers can easily identify and select the plants best suited for their revegetation needs.

Researchers are conducting this demonstration in cooperation with the Natural Resources Conservation Service.

ACCOMPLISHMENTS AND RESULTS

Poor initial stands of selected vegetation and an unmanageable stand of weeds caused the bottomland site to be dropped from evaluation. Decision-makers maintained that the time involved in reestablishing the site would leave no time for evaluating it.

Controlled traffic or access was begun on the remaining sites at a low rate because of the extended drought.

The disturbed upland lawn (barracks area with extensive foot traffic) experienced generally good establishment after some replanting. Three varieties show promise despite the drought.

The disturbed upland lawn (with tire and track traffic) had some difficulty establishing because of the drought and poor soil conditions. Researchers halved planned traffic on this area to maintain the vegetation. A number of accessions thrived despite the dry weather and vehicle traffic.

The wooded upland area (bivouac area) was the best established site; it was shady and little used.

The disturbed upland area (small arms range), though harsh and poorly established, had three accessions that show promise. Adding to the stress of the site, parts of it were bladed to smooth out the bullet furrows. This unplanned blading defeated the purpose of the trial. Sufficient plots may remain to continue evaluations.



**FOLLOW-ON PROGRAM
REQUIREMENTS**

- Review installations and select demonstration sites.
- Initiate project on all sites by preparing them for planting.
- Plant projects on all installations.
- Review all sites for stands and replant if necessary.
- Monitor project; make sure vehicle and foot traffic is applied according to the project plan.
- Record results, summarize data, prepare technical report and publish results.

POINT OF CONTACT

David Lorenz

PROGRAM PARTNERS

U.S. Army Environmental Center
Natural Resources Conservation Service
Fort Leonard Wood, Missouri



◆ ORDNANCE EMISSIONS TEST PROGRAM

Military installations need to characterize the emissions generated by munitions during training and testing activities. The Ordnance Emissions Test Program will provide the U.S. Army and Department of Defense (DoD) with data to help them assess the environmental impacts from munitions use, as well as build various models and health and risk assessments.

PURPOSE

- To obtain data and identify models that quantify the emissions generated from smoke and pyrotechnic items containing explosives or other energetic fills.
- To provide the Army with data to assess the potential air emissions.
- To create defensible data to be used for fate, transport and effect work.

BENEFITS

The data generated from this effort will help the Army and Army installations assess the environmental impacts of using munitions during training and testing operations. The emissions data can be used to feed various models (such as air, fate and transport) and support the generation of health and risk assessments. Installations can also use the data to meet Emergency Planning and Community Right-to-Know Act or the Toxic Release Inventory reporting requirements. Environmental restrictions on training U.S. military personnel will be minimized, due to more scientific data. Future cleanup costs may be reduced. Furthermore, the environmental stewardship observed will enhance both public image and trust.

TECHNOLOGY USERS

Army and DoD installations.
U.S. Army Installations
U.S. Army Research Laboratory
U.S. Army Corps of Engineers – Waterways Experiment Station

DESCRIPTION

The U.S. Army Environmental Center (USAEC) has developed a test program to identify and quantify the emissions that result from weapons firing and from the use of pyrotechnic devices. The data to be gathered will provide information on the concentration, transport, dispersion and fate of the emission products. The requirement for this information was identified as a result of the Administrative Orders issued by the U.S. Environmental Protection Agency (EPA) Region I, which severely restricted training operations at the Massachusetts Military Reservation. The Army questioned the validity of the claims made by the EPA Region I, but was unable to provide data regarding training range emissions and the fate and transport of those emissions in the environment. This test program is focused on obtaining and developing data such that the Army will be able to present an incontrovertible case for the continuation of operations or at least limit the breadth of restrictions to those activities that are in fact causing peril. The three distinct but related project areas to quantify emissions have been developed as follows:



1) Firing Point Emission Study

This effort will develop data on the emissions resulting from weapons firing at the firing position and associated emissions factors. The focus of the effort will be to quantify the emissions, develop emissions factors and evaluate the fate of emissions from representative U.S. Army weapon system ammunition classes. The data generated will support the U.S. Army and U.S. Army installations in assessing the environmental impact of weapons firing as a part of training and testing operations. Limited data exists on the emissions associated with weapons firing. Research efforts, such as those conducted by Illinois Institute of Technology (IIT) Research Institute on small caliber (5.56-mm) and large caliber (105-mm), were very limited in scope. A phased approach has been developed. Phase I, completed in 1998, encompassed a data search and analysis, test matrix and methodology development, model development, and an interim report. Phase I aimed to establish item similarities and data crossover so that the item test matrix and costs are minimized. Phase II involves actual weapons firing at the Aberdeen Test Center, Aberdeen Proving Ground, Maryland, with sampling, analysis and modeling, utilizing the Phase II sampling/modeling results to develop emission factors for specific weapons systems and ammunition types.

2) Characterization of Smoke and Pyrotechnic Emissions

This effort will develop data on the emissions resulting from smoke grenades and flare use during training and testing. A phased approach will be used to accomplish this task. Phase I encompasses a comprehensive data search followed by actual testing to develop data on the emissions resulting from smoke grenade and flare use. The emissions will be characterized in the Bang Box at the Dugway Proving Ground, Utah, for various smoke grenades (colored and uncolored) and flare devices (colored and uncolored). Results of these characterization efforts will then be used to generate emission factors for the various items. The emission factors can then be used in conjunction with standard dispersion models to estimate downwind concentrations and rates of deposition.

3) Exploding Ordnance Emissions

This effort identifies and evaluates the fate of explosive compounds in projectiles that have properly functioned during training and testing operations. Efforts will be focused to assess and document the completeness of reaction, and to quantify the emission residuals and byproducts from explosive detonation of military projectiles. The dispersal of the residuals and byproducts in air, soil and water, as well as factors affecting their environmental degradation and transport, will be evaluated. A phased approach is planned. Phase I efforts consisted of a significant data search and review, test matrix and methodology development, and model identification. One aspect of test methodology will be to assess the potential of using small-scale detonations, which mimic much larger sized ordnance. It is envisioned that at least one full-scale detonation will be required, and those



results will be used for verification of the test methodology. Phase II will provide for the actual testing and development of emission factors. Phase III of this effort involves a comprehensive study on the environmental fate and transport of the emission products in the environment.

For all of the emissions studies, it is known that in perfect combustion of an organic (carbon-containing) substance, only carbon dioxide and water are created. However, because explosions and other types of combustion do not always take place under optimal conditions, and because there are other substances included in these items, researchers look for many other substances in addition to carbon dioxide and water. During testing, the item being evaluated is placed in the testing chamber, and the system used to collect the emissions from the ignition of the item is activated. Upon detonation, the smokes produced are collected through a vacuum system. The samples collected are then processed by chemists to determine amounts of any substances present. Chemists analyze the samples collected for over 300 different substances that can be byproducts of any combustion. The airborne compounds sampled for during these tests included total suspended particulate, particulate matter that was smaller than 10 microns, metals, volatile organic compounds, dioxins and furans, carbon monoxide, and similar compounds that might lead to public health concerns.

The tests were also meticulously videotaped with high-speed film, enabling researchers to play back the video and measure the fire plumes and smoke patterns from the detonations. The temperature and velocity of the firing are also being measured. The information obtained can be used by modelers to determine what is ultimately happening to the emissions and their effects, if any.

Efforts have been made to document and assess existing data, identify applicable models, and develop test matrices and methodologies relative to characterizing emissions generated by Army munitions. Testing of numerous items will provide "real world" emissions data.

Furthermore, assessments can be performed with fate and transport work; should perforation occur, the effects can be determined and monitored.

ACCOMPLISHMENTS AND RESULTS

Testing of 22 items for smoke and pyrotechnic and firing point emissions was completed. Reports are being generated recording emission factors, actual concentrations and analysis of emissions.

The Environmental Protection Agency, Research Triangle Park has been reviewing Detailed Test Plans prior to the firing or detonating of the ordnance. Their comments and approval of the plans has added great validity to the testing.

FOLLOW-ON PROGRAM REQUIREMENTS

- 50 various tests are to be completed in fiscal year 2000 at Dugway Proving Ground and the U.S. Army ATC.



- Completion of documents publishing emission factor results.
- Publishing of emission factors in the EPA's standard document (AP-42)

POINT OF CONTACT

Tamera Clark

PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Army Aberdeen Test Center
U.S. Army West Desert Test Center, Dugway Proving Ground, Utah

A decorative graphic consisting of a large black square with a white border, slightly offset from a smaller white square. Four diamonds are placed at the corners: a black diamond at the top-left, a white diamond at the top-right, a white diamond at the bottom-right, and a black diamond at the bottom-left.

*OTHER
TECHNOLOGY
PROGRAMS*



◆ TRI-SERVICE ENVIRONMENTAL TECHNOLOGY WORKSHOP

In this age of decreasing funds, it is important for military services to leverage available resources and information. The Tri-Service Environmental Technology Workshop provides such an opportunity. The workshop is a forum for technical exchange and interaction on environmental technology strategies, initiatives, demonstrations and products.

PURPOSE

To provide a forum for technical exchange and interaction on environmental technology strategies, initiatives, demonstrations and products.

BENEFITS

By combining efforts with the Navy and Air Force, the U.S. Army reduces its funding needs to one-third of the workshop's total cost. The workshop also helps disseminate information across the services, reducing the "reinventing the wheel" syndrome. Combining what could be three conferences into one also reduces personnel travel expenses and time away from the office.

TECHNOLOGY USERS

Department of Defense (DoD) installations.

DESCRIPTION

In 1995, the U.S. Army Environmental Center (USAEC) hosted the DoD Environmental Technology Workshop. Bringing together the three military environmental support centers, this venue offered the opportunity for a unified position on environmental technology. The services recognized the need to share information. Since then, the services have supported and USAEC has hosted the annual Tri-Service Environmental Technology Workshop.

USAEC remains the host agency for the workshop and chair of the organizational committee. The organizational committee includes an individual from each service's environmental support center and an individual from each service's Environment, Safety and Occupational Health office. The committee's main role is to review and select abstracts for platform presentation; it performs other functions as necessary. The balance of the effort is handled by USAEC and the support contractor, Science and Technology Corporation.

Workshop presentations focus on mature technologies of timely interest to participants. Emphasis is placed on technologies that are "field ready," are currently being demonstrated, or have been demonstrated. This workshop is supported by the Tri-Service Environmental Support Centers Coordinating Committee.

ACCOMPLISHMENTS AND RESULTS

The 1998 Tri-Service Environmental Technology Workshop, held August 18 to 20 in San Diego, California, was well attended, despite an overall reduction in travel funds for government employees and contractors. It included 33 exhibitors and 64 technical presentations. The plenary session included presentations from USAEC, the Director, Directorate of Research and Development for the Army, the Air Force Center for Environmental Excellence, and the Naval Facilities Engineering Service Center. A tour of several Navy Environmental Leadership Projects/Sites at the Naval Air



Station, North Island, was offered to attendees. The 1998 proceedings are available on the USAEC Web site.

FOLLOW-ON PROGRAM REQUIREMENTS

Members of the organization committee will conduct discussions on the next Tri-Service Environmental Technology Workshop, tentatively scheduled for FY 2001.

POINT OF CONTACT

Darlene F. Bader

PROGRAM PARTNERS

U.S. Army Environmental Center
Office of the Director of Environmental Programs
Office of the Assistant Secretary of the Navy for Installations and Environment
Headquarters, Air Force
Naval Facilities Engineering Service Center
Air Force Center for Environmental Excellence

PUBLICATIONS

Report Number SFIM-AEC-ET-CR-96187 (Proceedings from 1996 workshop).

Report Number SFIM-AEC-ET-CR-9705 (Proceedings from 1997 workshop).

◆ **U.S. ARMY ENVIRONMENTAL (USER) REQUIREMENTS AND TECHNOLOGY ASSESSMENTS PROCESS AND WEB SITE**

During the first 15 years of Army environmental research, most Research, Development, Test and Evaluation (RDT&E) goals and objectives were established through informal coordination within the Army development community. Given greater emphasis on relevance to Army users, a more rigorous, requirements-based approach was developed in the early 1990s. Since 1993, the environmental user requirements process has been formalized into a two-year cycle aligned with the Program Objective Memorandum process.

PURPOSE

To serve as the Army Headquarters' central repository for environmental user requirements and related information; to present the Army's validated and prioritized environmental user requirements to help the RDT&E community identify opportunities for developing and demonstrating improved environmental systems; and to identify applicable off-the-shelf technologies to help Army users make informed decisions on technologies that are better, faster and more cost-effective.

BENEFITS

In addition to satisfying the annual Department of Defense (DoD) tri-service reporting requirement to the Environmental Security Technology Requirements Group (ESTRG), the U.S. Army Environmental (User) Requirements and Technology Assessments (AERTA) process enhances communication between the "users" of environmental technologies and the



Army's environmental RDT&E community. It gives the RDT&E community a better understanding of users' environmental technology requirements with associated performance metrics, their priorities, and the Army's cost of living with the problem, all of which provide the basis for developing RDT&E environmental technology management plans. AERTA provides Army installations with information on the development and availability of faster and more cost-effective environmental technologies. Organizations with technology requirements can use AERTA to identify and share "lessons learned" in a time of shrinking resources.

TECHNOLOGY USERS

Army and DoD major commands and installations use technologies to satisfy their environmental requirements. The AERTA Web site documents technology needs from four user communities: (1) users responsible for installation infrastructure; (2) users responsible for weapons systems acquisition; (3) major commands that use these weapons systems; and (4) agencies responsible for collecting and tracking needs related to infrastructure and weapons systems.

DESCRIPTION

From 1992 to 1994, meetings were held to facilitate the collection and development of an initial database of approximately 200 environmentally related operational problems throughout the Army. The list of requirements was screened to focus on those requiring long-term research and development, then prioritized through a voting process based on six ranking criteria: (1) environmental impact; (2) impact on readiness; (3) annual cost of operating with the unresolved requirement; (4) extent of the problem throughout the Army; (5) impact on quality of life; and (6) regulatory time limits.

The Office of the Assistant Chief of Staff for Installation Management, through the U.S. Army Environmental Center (USAEC), refined and updated these requirements from 1995 through 1997, expanding the scope of the effort into the Technology User Needs Survey (TNS). The Army's environmental databases were analyzed to maximize existing user environmental reporting, and several site visits were conducted across Army installations and major commands. These actions refined the qualitative and quantitative data on user needs and allowed requirements to be compiled in a common format that supports the DoD Tri-Service Environmental Quality Requirements Strategy (prepared by ESTRG). The updated requirements were presented at technology team meetings in 1996 and 1997 for review and validation. The list was narrowed to 142 requirements in 1997 and further focused to 44 requirements in 1999, which were prioritized within each program area (i.e., pillar) by the user community.

The TNS was retailored as a Web site, enhanced to include off-the-shelf and developing technology information, and renamed AERTA. AERTA is a "living" document/database that is continually refined according to the ACSIM's user-requirements process and schedule. As the technology teams develop and execute RDT&E programs in response to these needs, the user representatives and stakeholders will adjust the need statements and related performance metrics (i.e., measurements for determining when the need is



considered completely satisfied). On a biennial basis, the user representatives assess each program area to determine if a readjustment of the need statements, performance metrics and supporting documentation is warranted. Completion of the first cycle for user-requirement development, under the formal AERTA process, was accomplished in April 1999.

An electronic copy of the Army's environmental technology needs can be reviewed on the Defense Environmental Network and Information eXchange (DENIX) at www.denix.osd.mil/denix/DoD/Policy/Army/Aerta/default.html. The advantage of storing information on the DENIX Web site is that access is restricted to DoD employees and contractors with approved accounts and passwords. To address problems of data management and satisfy the concerns of having certain sensitive items exposed to the public, USAEC prepares two versions of the Army's environmental technology requirements on the World Wide Web. The first version contains unfiltered information and is maintained on the DENIX Web site. A second version, from which "sensitive" information not readily needed by the public has been deleted, is on the ESTRG Web site at xre22.brooks.af.mil/estrg/estrgtop.htm. The Office of the Secretary of Defense ESTRG site will also identify primary points of contact (one to two per program area, per service) as a gateway for interested parties outside DoD.

ACCOMPLISHMENTS AND RESULTS

The AERTA process focused the requirements into 44 validated mission-critical environmental needs. The AERTA process was validated in fiscal year 1999 with cooperation of numerous user and RDT&E community representatives across the four program areas. The requirements portion of AERTA is updated biennially in the even fiscal years, with the technology assessments portion updated quarterly.

LIMITATIONS

The technology teams are responsible for screening out needs for which the solutions clearly do not involve technology.

POINT OF CONTACT

Erik Hangeland

PROGRAM PARTNERS

U.S. Army Environmental Center
Members of the Army RDT&E community
Army Technology Users

PUBLICATIONS

Army Technology Needs Survey.

Army Environmental Requirements and Technology Assessments. World Wide Web site (www.denix.osd.mil/denix/DoD/Policy/Army/Aerta/default.html).

FY99 Army Environmental Requirements and Technology Assessments, Final Report. July 1999.



◆ U.S./GERMANY ENVIRONMENTAL TECHNOLOGY DATA EXCHANGE AGREEMENT

Through Data Exchange Agreements (DEAs), the United States (U.S.) and other countries can share technical expertise and data to tackle common challenges and improve quality of life. The Department of Defense (DoD) has administered an environmental technology exchange agreement with Germany for more than a decade.

PURPOSE

To promote sharing of environmental research and development (R&D) information among U.S. and German engineers and scientists. The agreement's focus was expanded in 1994 to include joint field demonstrations.

BENEFITS

Sharing information and expertise will benefit technology research and development efforts, and save R&D costs.

DESCRIPTION

Through DEAs, the United States and other countries can share technical expertise and data to tackle common challenges and improve quality of life. The DoD has administered an environmental technology DEA with Germany since 1986. Under the agreement, the U.S. and Germany may share environmental information directly. In addition to this regular activity, the technical project officers of each DEA participate in periodic progress reviews, and general exchange meetings are held every 18 months. Meeting locations alternate between U.S. and German hosts.

The U.S./Germany environmental technology DEA consists of four individual agreements:

- DEA 1311, Hazardous Materials/Pollution Prevention/Air;
- DEA 1520, Soil Remediation;
- DEA 1521, Water Remediation;
- DEA 1522, Demilitarization and Disposal of Conventional Munitions.

Since the inception of the Agreement, the U.S. Army Environmental Center (USAEC) has taken a leadership role as the Soils DEA technical project officer, or representative of all U.S. military agencies doing environmental research or development work on soils characterization and remediation.

ACCOMPLISHMENTS AND RESULTS

In addition to sharing valuable scientific data and lessons learned, USAEC has sponsored a cooperative U.S./Germany field demonstration of Site Characterization and Analysis Penetrometer System technology at Rhein Main Air Base, Germany.

A new cooperative demonstration of electrokinetics treatment of metals-contaminated soils from a North American Treaty Organization grenade range is under development.



FOLLOW-ON PROGRAM REQUIREMENTS

In FY 2000, leadership of the Soils DEA will transition to the U.S. Army Engineer Research and Development Center, Waterways Experiment Station. As a charter member of the DEA, USAEC will continue to support international environmental technology transfer.

POINT OF CONTACT

Mark Hampton

PROGRAM PARTNERS

Deputy Assistant Secretary of the Army for Environment, Safety and Occupational Health (U.S. general officer for the DEA)
U.S. Army Edgewood Chemical and Biological Center (U.S. DEA project officer)
U.S. Army Environmental Center, Pollution Prevention and Environmental Technology Division (DEA 1520)
U.S. Army Armament Research, Development and Engineering Center (DEAs 1311 and 1522)
U.S. Air Force Research Lab (DEA 1521)
Federal Office for Defense Technology and Procurement (German DEA project officer)
German Federal Armed Forces Scientific Institute for Protection Technologies (German technical project officer for DEA 1520)

PUBLICATION

Proceedings of the 1997 Environmental Technology Data Exchange Meeting. April 1998.

**UXO FORUM**

In a concerted effort to bring together the best minds from all corners of the world, the annual UXO Forum addresses technology, policy and regulatory issues related to unexploded ordnance (UXO). Participants acquire a greater understanding of UXO issues, how they affect our world today, and the implications for the 21st century.

PURPOSE

To produce, manage and host a conference that addresses UXO technology, policy and regulatory issues.

BENEFITS

The conference brings together a diverse audience to exchange ideas and information on UXO.

DESCRIPTION

The UXO Forum addresses technology, policy and regulatory issues related to unexploded ordnance.

UXO Forum 1999 was sponsored by the U.S. Department of Defense Explosives Safety Board (DDESB) and hosted by the U.S. Army Environmental Center (USAEC), in cooperation with the Joint UXO Coordination Office, the U.S. Army Corps of Engineers-Huntsville Division, the U.S. Army Project Manager for Non-Stockpile Chemical Materiel, the Naval Explosive Ordnance Disposal Technology Division, the U.S. Air Force Wright



Laboratory and the National Association of Ordnance and Explosive Waste Contractors. The DDESB will sponsor the UXO/Countermining Forum.

ACCOMPLISHMENTS AND RESULTS

USAEC produced and hosted UXO Forum 1999 in Atlanta, Georgia, from May 25 to 27. Approximately 650 individuals attended.

FOLLOW-ON PROGRAM REQUIREMENTS

Include the five Joint Unexploded Ordnance Coordination Office mission areas into Forum 2000. Plan and conduct the UXO/Countermining at Anaheim, California, from May 2 to 4.

POINT OF CONTACT

Darlene Edwards

PROGRAM PARTNERS

U.S. Army Environmental Center
U.S. Department of Defense Explosives Safety Board
Unexploded Ordnance Center of Excellence
U.S. Army Corps of Engineers-Huntsville Division
U.S. Army Project Manager for Non-Stockpile Chemical Materiel
Naval Explosive Ordnance Disposal Technology Division
U.S. Air Force Wright Laboratory
National Association of Ordnance and Explosive Waste Contractors
Headquarters, U.S. Army Corps of Engineers Research and Development

PUBLICATIONS

UXO Forum 1997, 1998, and 1999 conference proceedings.



SCAPS

The Site Characterization and Analysis Penetrometer System (SCAPS) program began in 1987 under sponsorship of the U.S. Army Toxic and Hazardous Materials Agency (now the U.S. Army Environmental Center [USAEC]) to address the need for rapid site characterization of soil contamination at U.S. Army facilities. The program evolved into a Tri-Service (Army, Air Force and Navy), multi-year research, development, and technology demonstration program with additional funding by the Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP). The U.S. Department of Energy and U.S. Environmental Protection Agency (EPA) also participated in the program. USAEC took the lead for coordinating SCAPS sensor development and demonstration efforts among the Department of Defense Tri-Service agencies.

SCAPS consists of a commercial cone penetrometer unit mounted on the custom-designed bed of a 20-ton truck. The truck houses a mechanical room for the cone penetrometer and a data analysis room for operational and diagnostic computers and instrumentation. A variety of sensor probes can be attached to the cone penetrometer to investigate soil geophysical properties, or to identify classes of contaminants such as petroleum, solvents, metals and explosives. SCAPS operators use a 20-ton hydraulic press mounted in the truck to push the sensors up to 150 feet into the soil. The SCAPS systems relay information on subsurface contaminants to the surface for immediate analysis and interpretation. The final display products SCAPS provides can range from individual push charts to cumulative three-dimensional depictions of the subsurface.

The original goal of this tri-service endeavor was to coordinate research, development, demonstration and technology transfer efforts for the production of cone penetrometer deployed sensors and samplers. The team focused on the production of tools to characterize sites with petroleum, volatile organic compounds (VOCs), metals and explosives contamination. This goal was met, and sensor systems are available to characterize contaminated sites.

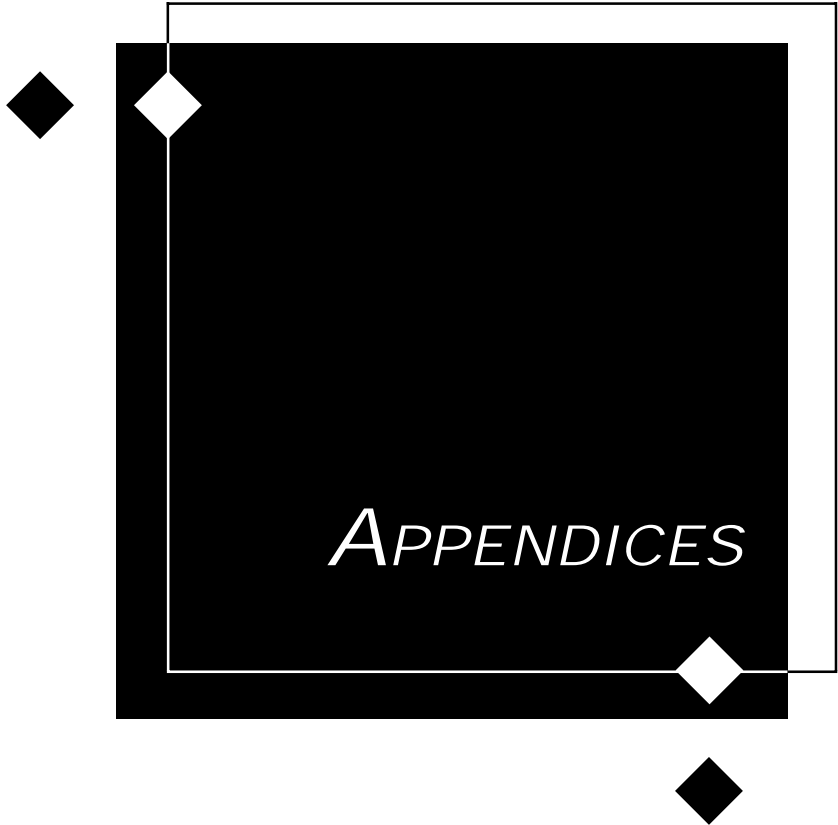
Regulatory acceptance is the key to successful technology transfer. Although there is no designated path for the pursuit of regulatory acceptance of innovative technologies, the SCAPS program has successfully participated in a variety of evaluation programs. The pursuit of regulatory acceptance began with the Laser Induced Fluorescence (LIF) sensor in the EPA Superfund Innovative Technology Evaluation program. From there, the LIF entered the EPA Consortium for Site Characterization Technology and Interstate Technology Regulatory Cooperation Workgroup (ITRC), formerly the WGA-ITRC. In addition, a standard practice for LIF has been accepted by the American Society of Testing and Materials (ASTM) and given the designation D-6187-97.

Additional highlights of the program include:

- Eleven patents and four patent applications granted
- Non-Exclusive and sub-licenses issued



- EPA Method 8265 issued for VOC analysis
- Eight SCAPS trucks operated by three federal agencies
- Reciprocity with 27 states for approval to use SCAPS has been achieved through the ITRC Workgroup
- ASTM Standard Practice for LIF: D-6187-97
- Five technical standards, methods or regulatory guidelines for use of SCAPS chemical sensor and sampler probes have been written
- Approximately 100 technical papers were published
- SCAPS Web site established
- Documented savings versus conventional characterization methods
- Over 200 sites characterized with SCAPS technologies.





◆ ACRONYMS

AAP	Army Ammunition Plant
ABRP	Agriculture-Based Bioremediation Program
ACSIM	Assistant Chief of Staff for Installation Management (Army)
AD	Army Depot
ADPA	American Defense Preparedness Association
AERTA	Army Environmental (User) Requirements and Technology Assessments
AFCEE	Air Force Center for Environmental Excellence
ALT	Acquisition, Logistics and Technology
AO	Administrative Orders
APC	Armored Personnel Carrier
APG	Aberdeen Proving Ground, Maryland
AR	Army Regulation
ARDEC	U.S. Army Armament Research Development and Engineering Center
ARL	U.S. Army Research Laboratory
ASA	Assistant Secretary of the Army
ASTM	American Society for Testing and Materials
ATC	Aberdeen Test Center
ATSC	U.S. Army Training Support Center
ATTACC	Army Training and Testing Area Carrying Capacity
BAA	Broad Agency Announcement
BRAC	Base Realignment and Closure
BTEX	Benzene, toluene, ethylbenzene and xylene
CARD	Cost Analysis Requirements Description
CA-WIPT	Cost Analysis Working-Level Integrated Product Team
CEAC	U.S. Army Cost and Economic Analysis Center
CE-MP	U.S. Army Corps of Engineers Military Programs Office
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERL	U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratories
CFR	Code of Federal Regulations
CONUS	Continental United States
COTS	Commercial Off-The-Shelf
CRADA	Cooperative Research and Development Agreement
CRB	Cost Review Board
CRREL	U.S. Army Engineer Research and Development Center-Cold Regions Research and Engineering Laboratory
CTC	Concurrent Technologies Corporation
CX	Categorical eXclusion
DA	Department of the Army
DASA/ESOH	Department of the Assistant Secretary of the Army/Environmental Safety and Occupational Health
DDESB	Department of Defense Explosives Safety Board
DEA	Data Exchange Agreement
DENIX	Defense Environmental Network and Information eXchange



DLA	Defense Logistics Agency
DNT	Dinitrotoluene
DoD	Department of Defense
DOE	Department of Energy
DRE	Dead Reckoning Error
DSERTS	Defense Site Environmental Restoration Tracking System
DTP	Detailed Test Plans
EA	Environmental Assessment
EDYS	Dynamics simulation model
EIS	Environmental Impact Statement
EO	Executive Order
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPP	Environmentally preferable products
ERDC	Engineer Research and Development Center
ESH	Environmental, safety and health (evaluations)
ESTCP	Environmental Security Technology Certification Program
ESTRG	Environmental Security Technology Requirements Group
FONSI	Finding of No Significant Impact
FORSCOM	U.S. Army Forces Command
FRH	Fire Resistant Hydraulic Fluid
FRTR	Federal Remediation Technologies Roundtable
FUDS	Formerly Used Defense Sites
FY	fiscal year
GAC	Granular activated carbon
GMF	Granular media filter
GMS	Groundwater Modeling System
gpm	gallons per minute
GSA	General Services Administration
GWETER	Groundwater Extraction and Treatments Effectiveness Reviews
HAP	Hazardous air pollutant
HEPA	High efficiency particulate air
HM	Hazardous materials
HMMP	Hazardous Material Management Program
HMX	Cyclotetramethylene
HSMS	Hazardous Substance Management System
HW	Hazardous waste
IAAP	Iowa Army Ammunition Plant
IL&E	Installations, Logistics and Environment
IOC	U.S. Army Industrial Operations Command
ISDN	Integrated Services Digital Network
ITAM	Integrated Training Area Management
ITR	Independent Technical Reviews



JOAAP	Joliet Army Ammunition Plant, Illinois
LAP	Load, assemble and pack
LBCC	Land-Based Carrying Capacity
LCAAP	Lake City Army Ammunition Plant, Missouri
LCTA	Land Condition Trend Analysis
M	million
MAAP	Milan Army Ammunition Plant, Tennessee
MACOM	Major Army command
MCAAP	McAlester Army Ammunition Plant, Oklahoma
NAPL	Non-aqueous phase liquid
NATO	North Atlantic Treaty Organization
NAWS	Naval Air Weapons Station
NDCEE	National Defense Center for Environmental Excellence
NDIA	National Defense Industry Association
NEPA	National Environmental Policy Act
NG	Nitroguaninide
NRCS	Natural Resources Conservation Service
NSWC	Naval Surface Warfare Center
ODEP	Office of the Director of Environmental Programs (Army)
OPA	Other Procurement Army
ORNL	Oak Ridge National Laboratory
OSD	Office of the Secretary of Defense
OSHA	Occupational Safety and Health Administration
P2	Pollution prevention
P2&ETD	Pollution Prevention and Environmental Technology Division
P2IF	Pollution Prevention Investment Fund
PEO	Program executive officer
PEPS	Plasma Energy Pyrolysis System
PM	Program manager
POE	Program Office Estimate
POLs	Petroleum, oils and lubricants
ppb	Parts per billion
ppm	Parts per million
R&D	Research and Development
R3M	Range Rule Risk Model
RBCA	Risk Based Corrective Action
RCRA	Resource Conservation and Recovery Act
RDT&E	Research, Development, Test and Evaluation
RDX	Royal Demolition Explosive
REC	Record of Environmental Consideration
ROD	Record of Decision
RTP	Research Triangle Park
RUSLE	Revised Universal Soil Loss Equation



SABRE	Simplot Anaerobic Bioremediation Ex-situ (bioslurry) process
SACON	Shock Absorbing Concrete
SCAPS	Site Characterization and Analysis Penetrometer System
SERDP	Strategic Environmental Research and Development Program
SOW	Statement of Work
SVE	Soil vapor extraction
TCA	Tactical Concealment Area
TCAAP	Twin Cities Army Ammunition Plant, Minnesota
TCE	Trichloroethylene
TNS	Technology (User) Needs Survey
TNT	Trinitrotoluene
TPH	Total petroleum hydrocarbons
TRADOC	U.S. Army Training and Doctrine Command
TRI	Toxic Release Inventory
TSP	Total suspended particulate
TVA	Tennessee Valley Authority
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
USAEC	U.S. Army Environmental Center
USAIC	U.S. Army Infantry Center
USMA	U.S. Military Academy
UXO	Unexploded ordnance
VOC	Volatile organic compound
WES	U.S. Army Engineer Research and Development Center-Waterways Experiment Station
WMRD	Weapons and Materials Research Directorate



◆ PROGRAM PARTNERS

P2&ETD specialists often team with experts from across the Army, Navy, Air Force, Department of Defense, other federal and state government agencies, private industry and academia. Our partners include:

Air Force Center for Environmental Excellence
Alliant TechSystems
Anniston Army Depot, Alabama
Argonne National Laboratory

Camp Bullis, Texas
Camp Guernsey, Wyoming
Camp Ripley, Minnesota
Combat Training Support Directorate, Deputy Chief of Staff-Training, Training and Doctrine Command
Concurrent Technologies Corporation
Corpus Christi Army Depot, Texas

Deputy Assistant Secretary of the Army for Environmental, Safety, and Occupational Health (U.S. General Officer for the DEA)
Deputy Under Secretary of Defense for Environmental Security
Dugway Proving Ground, Utah

Environmental Security Technology Certification Program

Federal Office for Defense Technology and Procurement (Germany)
Federal Remediation Technologies Roundtable
Fort Bliss, Texas
Fort Campbell, Kentucky
Fort Carson, Colorado
Fort Hood, Texas
Fort Jackson, South Carolina
Fort Knox, Kentucky
Fort Leonard Wood, Missouri
Fort Pickett, Virginia
Fort Rucker, Alabama
Fort Stewart, Georgia

German Federal Armed Forces Scientific Institute for Protection Technologies

Iowa Army Ammunition Plant, Iowa



Joliet Army Ammunition Plant, Illinois

Lake City Army Ammunition Plant, Missouri
Logicon
Louisiana State University

Major Army Commands
McAlester Army Ammunition Plant, Oklahoma
Milan Army Ammunition Plant, Tennessee

National Association of Ordnance and Explosive Waste Contractors
National Defense Center for Environmental Excellence
National Guard Bureau
Natural Resources Conservation Service
Naval Aviation Depot – Cherry Point, North Carolina
Naval Explosive Ordnance Disposal Technology Division
Naval Facilities Engineering Command, Southwest Division
Naval Facilities Engineering Service Center
Naval Surface Warfare Center, Crane, Indiana
Naval Surface Warfare Center, Indian Head, Maryland

Oak Ridge National Laboratory
Office of the Assistant Secretary of the Navy for Installations and Environment
Office of the Director of Environmental Programs (Army)
Orchard Training Area, Idaho

Pall Aerospace
Patuxent River Naval Air Station, Maryland
Plasma Energy Applied Technology
Platinum International, Inc.
Point Mugu Naval Air Weapons Station, California
Program Executive Office-Standard Army Management Information Systems,
HSMS Project Office
Program Manager-Apache helicopter program
Program Manager-Comanche helicopter program

Range Rule Partnering Initiative

Teledyne Brown Engineering
Tennessee Valley Authority
The Boeing Company
Twin Cities Army Ammunition Plant, Minnesota



U.S. Air Force
U.S. Air Force Research Laboratory
U.S. Air Force Wright Laboratory
U.S. Army
U.S. Army Aberdeen Test Center
U.S. Army Armament Research Development and Engineering Center
U.S. Army Cold Regions Research and Engineering Laboratory
U.S. Army Corps of Engineers
U.S. Army Corps of Engineers - Huntsville Division
U.S. Army Cost and Economic Analysis Center
U.S. Army Edgewood Chemical and Biological Center (U.S. DEA project officer)
U.S. Army Engineer Research and Development Center-Cold Regions Research and Engineering Laboratory
U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratories
U.S. Army Engineer Research and Development Center-Waterways Experiment Station
U.S. Army Environmental Center
U.S. Army Environmental Center, Pollution Prevention and Environmental Technology Division
U.S. Army Forces Command
U.S. Army Industrial Operations Command
U.S. Army Military Academy, New York
U.S. Army Project Manager for Non-Stockpile Chemical Materiel
U.S. Army Research, Development, Test, and Evaluation community members
U.S. Army Space and Missile Defense Command
U.S. Army Tank-automotive and Armaments Command
U.S. Army Technology Users
U.S. Army Training and Doctrine Command
U.S. Army Training Support Center
U.S. Army West Desert Test Center, Dugway Proving Ground, Utah
U.S. Department of Agriculture
U.S. Department of Defense
U.S. Department of Defense Explosives Safety Board
U.S. Department of Energy
U.S. Environmental Protection Agency
U.S. Geological Survey
U.S. Navy
Unexploded Ordnance Center of Excellence

Vanguard Research Inc.

Warner-Robins Air Logistics Center, Georgia