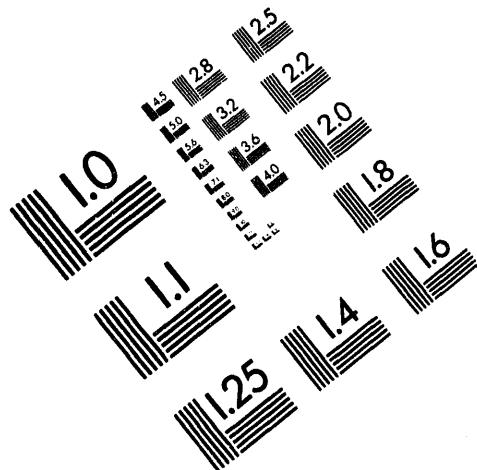




**AIIM**

**Association for Information and Image Management**

1100 Wayne Avenue, Suite 1100  
Silver Spring, Maryland 20910  
301/587-8202



1 of 1

**THE WESTERN ENVIRONMENTAL TECHNOLOGY OFFICE  
(WETO)  
BUTTE, MONTANA  
TECHNOLOGY SUMMARY**

**TABLE OF CONTENTS**

|  |            |
|--|------------|
| <b>Foreword .....</b>  | <b>iii</b> |
| <b>Introduction.....</b>   | <b>iv</b>  |
| <b>1.0      Office of Technology Development-Sponsored Projects .....</b>      | <b>1</b>   |
| <i>Heavy Metals Contaminated Soil Project</i>                                  |            |
| 1.1    Heavy Metals Contaminated Soil Project .....                            | 3          |
| 1.2    Heavy Metals Separation Technologies .....                              | 5          |
| <i>In Situ Remediation Integrated Program</i>                                  |            |
| 1.3    Biomass Remediation System .....  | 11         |
| <i>Minimum Additive Waste Stabilization Program</i>                            |            |
| 1.4    The Minimum Additive Waste Stabilization Program .....                  | 14         |
| <i>Resource Recovery Project</i>   |            |
| 1.5    Resource Recovery Project .....   | 19         |
| 1.6    Resource Recovery Project Technology Demonstrations .....               | 21         |
| <i>Buried Waste Integrated Demonstration</i>                                   |            |
| 1.7    Plasma Arc Technology Testing .....                                     | 23         |
| 1.8    Plasma Fixed Hearth Process .....                                       | 25         |
| <i>Mixed Waste Integrated Program</i>  |            |
| 1.9    Fixed Hearth Plasma Arc Treatment Process .....                         | 28         |
| <i>Pollution Prevention Program</i>  |            |
| 1.10   Department of Energy/U.S. Air Force<br>Memorandum of Understanding..... | 31         |

|            |   |           |
|------------|---|-----------|
| 1.11       | Spray Casting Project .....   | 33        |
| <b>2.0</b> | <b>Other Federal Agency and DOE Collaborative Projects .....</b>                                      | <b>37</b> |
| 2.1        | Mine Waste Technology Pilot Program.....  | 39        |
| 2.2        | Mine Waste Technology Pilot Program Activity III Projects .....                                       | 42        |
| 2.3        | U.S. Army Construction Engineering Research Laboratory Projects .....                                 | 45        |
| 2.4        | Army Vitrification.....   | 47        |
| 2.5        | Sodium Sulfide/Ferrous Sulfate .....  | 49        |
| <b>3.0</b> | <b>FY94 Activities Funded Through the Pittsburgh Energy Technology Center in Butte, Montana .....</b> | <b>51</b> |
| <b>4.0</b> | <b>How To Get Involved With DOE Environmental Management .....</b>                                    | <b>55</b> |
| <b>5.0</b> | <b>Acronym Listing .....</b>  | <b>61</b> |

## **FIGURES**

|      |  |    |
|------|--|----|
| 1.2a | Air-sparged Hydroclone Technology .....  | 5  |
| 1.2b | Schematic of the Campbell Centrifugal Jig Technology .....   | 6  |
| 1.2c | Centrifugal Gravity Separation Technology .....  | 7  |
| 1.2d | Column Flotation Technology .....  | 7  |
| 1.2e | Automated Mechanical Flow Technology .....   | 8  |
| 1.2f | High Gradient Magnetic Separation Technology .....   | 9  |
| 1.2g | SEPOR System.....  | 10 |
| 1.3  | Fractionation Separation Technology Process for macrophyte remediation of contaminated soils .....                               | 11 |
| 1.4  | Minimum Additive Waste Stabilization .....   | 15 |
| 1.5  | Resource Recovery Project .....  | 19 |
| 1.7  | Retech's PACT System at the MSE test facility, Butte, Montana .....  | 23 |
| 1.8  | Fixed hearth and plasma torch at Retech test facility .....  | 25 |
| 1.9  | Plasma Hearth Process Prototype Design .....   | 28 |
| 1.10 | The industrial processes of the Department of Energy/U.S. Air Force Memorandum of Understanding Program.....                     | 31 |
| 1.11 | Controlled Aspiration Process .....  | 33 |
| 2.1a | Headframe of mine shaft and waste piles at the Lilly/Orphan Bay Mine, site of the SRB Demonstration Project of the MWTTP .....   | 39 |
| 2.1b | The Mike Horse Mine adit, site of the Clay-Based Grouting Demonstration Project of the MWTTP .....                               | 40 |
| 2.1c | The Crystal Mine Complex, site of the Remote Mine Complex, site of the Remote Mine Site Demonstration Project of the MWTTP ..... | 40 |

## FOREWORD

This document has been prepared by the Department of Energy's (DOE) Environmental Management (EM) Office of Technology Development (OTD) to highlight its research, development, demonstration, testing, and evaluation (RDDT&E) activities funded through the Western Environmental Technology Office (WETO) in Butte, Montana. Technologies and processes described have the potential to enhance DOE's cleanup and waste management efforts, as well as improve U.S. industry's competitiveness in global environmental markets. The information has been assembled from recently produced OTD documents which highlight technology development activities within each of the OTD program elements. These Technology Summaries (as well as other OTD documents) can be obtained through the EM Central Point-of-Contact at 1-800-845-2096 and include the following:

*VOCs in Non-Arid Soils Integrated Demonstration, February 1994 - DOE/EM-0135P*  
*VOCs in Arid Soils Integrated Demonstration, February 1994 - DOE/EM-0136P*  
*Mixed Waste Landfill Integrated Demonstration, February 1994 - DOE EM-0128P*  
*Uranium in Soils Integrated Demonstration, February 1994 - DOE/EM-0148P*  
*Characterization, Monitoring, and Sensor Technology Integrated Program, February 1994 - DOE/EM-0156T*  
*In Situ Remediation Integrated Program, February 1994 - DOE/EM-0134P*  
*Buried Waste Integrated Demonstration, February 1994 - DOE/EM-0149P*  
*Underground Storage Tank Integrated Demonstration, February 1994 - DOE/EM-0122P*  
*Efficient Separations and Processing Integrated Program, February 1994 - DOE/EM-0126P*  
*Mixed Waste Integrated Program, February 1994 - DOE/EM-0125P*  
*Rocky Flats Compliance Program, February 1994 - DOE/EM-0123P*  
*Pollution Prevention Program, February 1994 - DOE/EM-0137P*  
*Innovative Investment Area, March 1994 - DOE/EM-0146P*  
*Robotics Technology Development Program, February 1994 - DOE/EM-0127P*

This document represents one in a series for each of DOE's Operations Offices and Energy Technology Centers.

For more information on activities funded through the WETO facility, please contact:

**Melvin W. Shupe, Manager**  
WETO  
(406) 494-7205

# INTRODUCTION

## DOE's Office of Technology Development

DOE's Environmental Management Office of Technology Development manages an aggressive national program for applied research, development, demonstration, testing, and evaluation (RDDT&E). This program develops high-payoff technologies to clean up the inventory of DOE nuclear component manufacturing sites and to manage DOE-generated waste faster, safer, and cheaper than current environmental cleanup technologies.

OTD programs are designed to make new, innovative, and more effective technologies available for transfer to users through progressive development. Technologies are demonstrated, tested, and evaluated in an effort to produce solutions to current problems. Transition of technologies into more advanced stages of development is based upon technological, regulatory, economic, and institutional criteria. New technologies are made available for use in eliminating radioactive, hazardous, and other wastes in compliance with regulatory mandates. The primary goal is to protect human health and prevent further contamination.

OTD technologies address three specific problem areas: 1) groundwater and soils cleanup; 2) waste retrieval and processing; and 3) pollution prevention. These problems are not unique to DOE but are associated with other Federal agency and industry sites as well. Thus, technical solutions developed within OTD programs will benefit DOE and should have direct applications in outside markets.

OTD's approach to technology development is an integrated process that seeks to identify technologies and development partners and facilitates the movement of a technology from applied research to implementation. In an effort to focus resources and address opportunities, OTD has developed **Integrated Programs (IPs)** and **Integrated Demonstrations (IDs)**. An *Integrated Program* focuses on developing technologies to solve specific aspects of waste management or environmental problems either unique to a site or common to many sites. Integrated Programs support applied research activities in key application areas required in each stage of the remediation process (e.g., characterization, treatment, and disposal). An *Integrated Demonstration* is a cost-effective mechanism that assembles a group of related and synergistic technologies to evaluate their performance individually or as a complete system for solving waste management and environmental problems from cradle to grave. In addition to the IDs and IPs, OTD supports crosscutting research and development through the Innovation Investment Area (IIA) Program and the Robotics Technology Development Program (RTDP).

OTD's technology maturation philosophy consists of three components: 1) *technology infusion* - technology transfer from industry, universities, and other Federal agencies; 2) *technology adoption* - shared technology demonstration among DOE laboratories, integrated demonstrations, and programs, and 3) *technology diffusion* - technology transfer from demonstration to industry. To enhance opportunities for technology commercialization, OTD is seeking

partnerships with private-sector companies during the technology development and demonstration phases. Industry partners will facilitate implementing these emerging technologies to solve the nation's environmental problems.

## **WETO'S Contributions**

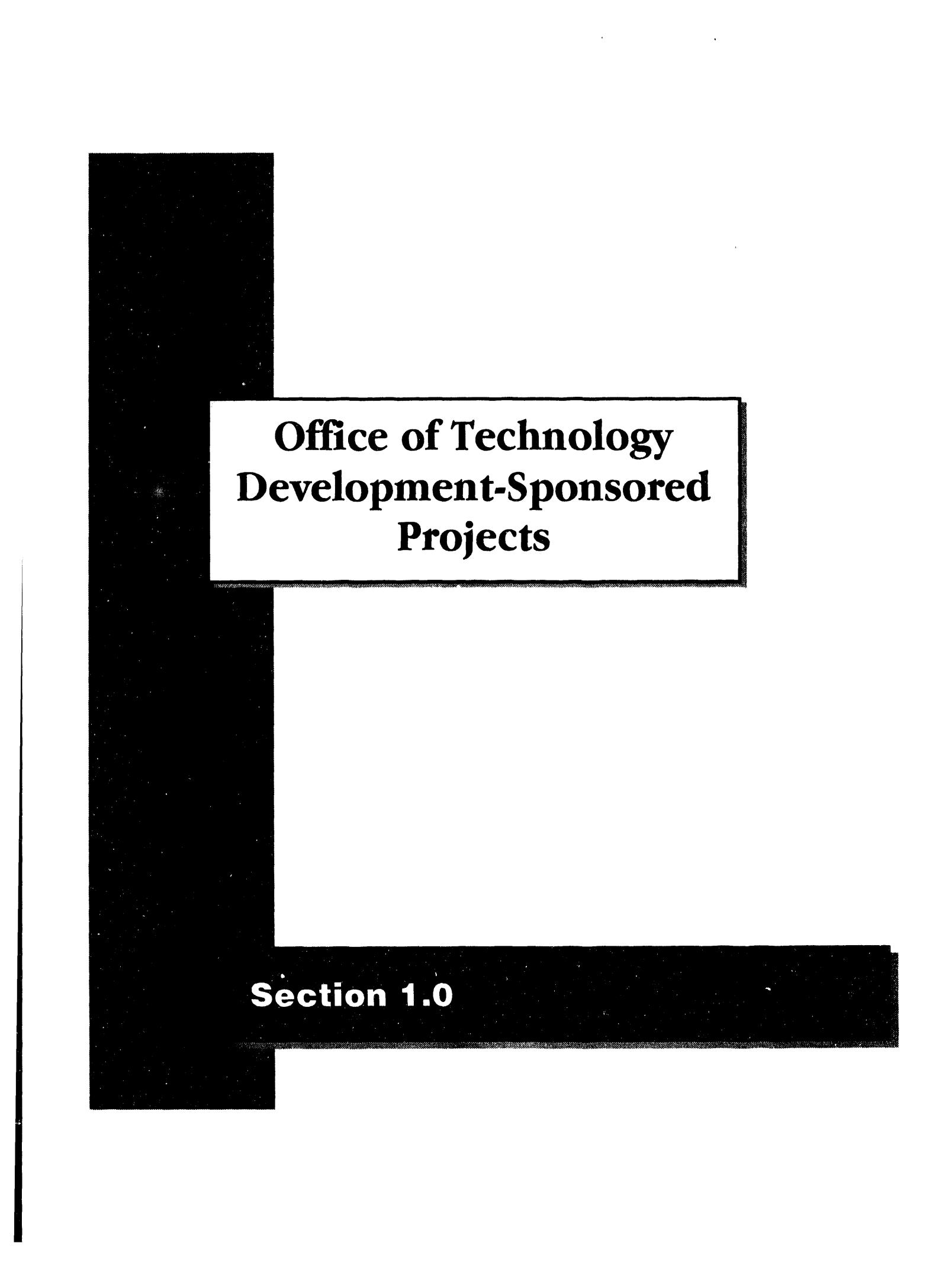
In April 1994, DOE announced its plan to transfer the Component Development and Integration Facility (CDIF) from the fossil energy to environmental management. Along with this transfer, the CDIF was renamed the Western Environmental Technology Office (WETO). WETO is a multipurpose engineering test facility, located in Butte, Montana, and managed by MSE, Inc. Established in 1974, WETO employs more than 200 highly skilled scientists, engineers, and technicians. WETO originally focused its work on coal-fired electric power generation projects and magnetohydrodynamic (MHD) component testing to find ways to burn coal more cleanly and efficiently. Now it seeks to contribute to environmental research by emphasizing projects to develop heavy metals removal and recovery processes, thermal vitrification systems, and waste minimization/pollution prevention technologies.

At the Butte facility projects are sponsored by multiple Federal agencies. DOE has teamed with the U.S. Environmental Protection Agency (EPA), the Department of Defense (DOD), and the Department of Interior (DOI) to develop and demonstrate innovative and cost-effective waste treatment technologies. This multiagency environment fosters cooperative research and data sharing, resulting in rapid transfer of new technologies to confront some of the nation's most urgent environmental cleanup problems.

WETO's environmental technology research and testing activities focus on the recovery of useable resources from waste. In one of WETO's areas of focus, groundwater contamination, water from the Berkeley Pit, which is located near the WETO site, is being used in demonstrations directed toward the recovery of potable water and metals from the heavy metal-bearing water. The Berkeley Pit is part of an inactive copper mine near Butte that was once part of the nation's largest open pit mining operation. The Pit contains approximately 25 billion gallons of Berkeley Pit groundwater and surface water containing many dissolved minerals. As part of DOE/OTD's Resource Recovery Project (RRP), technology is being demonstrated to not only clean the water but to recover metal values such as copper, zinc, and iron with an estimated gross value of more than \$100 million. When recovered, the Berkeley Pit waters could benefit the entire Butte valley with new water resources for fisheries, irrigation, municipal, and industrial use.

Renaming the Butte facility to WETO reflects the emphasis on environmental technology development and commercialization activities, which will focus on mine cleanup, waste treatment, resource recovery, and water resource management. Since the site has no record of radioactive material use and no history of environmental contamination/remediation activities, DOE-EM can concentrate on performing developmental and demonstration activities without the demands of regulatory requirements and schedules. Thus, WETO will serve as a national resource for the development of new and innovative environmental technologies.





## **Office of Technology Development-Sponsored Projects**

### **Section 1.0**



## **1.1 HEAVY METALS CONTAMINATED SOIL PROJECT**

---

### **TASK DESCRIPTION**

The primary objective of this project is to conduct treatability studies on soils from the Fernald site, INEL, Hanford site, Los Alamos National Laboratory (LANL), and any other DOE site that may wish to participate, for the following purposes:

- To determine the decontamination efficiencies of various processes using soils contaminated with plutonium, uranium, or other heavy metals from DOE sites;
- To provide sufficient data concerning physical and chemical characteristics of the contaminated soils from the various participating DOE sites to permit optimization of treatment processes for specific soil. These data include: soil particle size distribution, its radionuclide distribution as a function of particle size and physical and chemical characteristics; and
- To minimize uncertainties in performance efficiency and cost as related to decontamination of soils.

Successful decontamination of the soils is defined as a minimum 80% reduction in the volume of soil that will need to be disposed of or further treated.

---

### **TECHNOLOGY NEEDS**

The volume of contaminated soil requiring treatment and disposal throughout the DOE Complex is large. An estimated 20-25 million cubic feet of plutonium-contaminated soil exists at the Nevada Test Site (NTS) and the adjacent Tonopah Test Range (TTR), and one area at INEL contains 12 million cubic feet of soil contaminated with plutonium and other heavy metals. Other sites that have plutonium- or uranium-contaminated soil volumes of this order of magnitude or larger, which must be excavated and disposed of, include Operable Unit 2 at the Rocky Flats Plant, Operable Unit 5 at the Fernald Environmental Management Project (FEMP), LANL, and the DOE Richland Operations Office's Hanford, Washington, sites.

DOE has identified a need to develop, test, and demonstrate technologies for the remediation of soils contaminated by various metals. Such technology includes soil and vegetation removal, reduction of the volume of contaminated soil (the focus of this project), and ultimate disposal of the contaminated fraction. The costs of disposing of large volumes of contaminated soil in Land Disposal Facilities (LDFs) are relatively high. At the NTS, the current disposal fee for bulk wastes is \$10 per cubic foot, excluding excavation, handling and transportation expenses. Therefore, the theoretical minimum cost for disposing of plutonium-contaminated NTS soil would be on the order of \$200 million. Excavation using conventional methods produces waste volumes several times larger than the in situ contaminated volume. Estimates based upon the use of conventional excavation technologies indicate that the total remediation cost

could be as much as ten times larger, thus increasing NTS costs alone to as much as \$2 billion.

Technologies developed in this project have the potential to significantly reduce these costs by reducing the contaminated fraction to a maximum of 20% of the original volume.

## ACCOMPLISHMENTS

- Completed testing of seven off-the-shelf technologies with surrogate doped soils.
- Arranged receipt of soils from Fernald, LANL, INEL, Hanford, and Mound.
- Designed and built, at the University of Nevada in Reno, a lab capable of handling these contaminated soils, while ensuring the health and safety of the workers, public, and environment.
- Enlisted the analytical expertise of EPA in Montgomery, Alabama to ensure the accuracy of the testing and to provide the researcher with quality data from which to make their determinations.

## COLLABORATION/TECHNOLOGY TRANSFER

This project is being executed for DOE by the University of Nevada at Reno (UNR) through a subcontract from MSE, Inc. MSE has procured a Campbell Centrifugal Jig from Trans Mar, Inc., of Spokane, Washington, and an Air-sparged Hydrocyclone from Advanced Processing Technologies, Inc., of Salt Lake City, Utah, for testing at the UNR facility. The

United States Naval Academy (USNA) in Annapolis, Maryland, will supply the project with an air-classification unit obtained from the SEPOR system. High Gradient Magnetic Separation technology will be tested and evaluated at and by personnel from LANL. In addition, UNR has three technologies that will also be tested; these are a Knelson Concentrator, a Denver Cell and a Column Flotation technology. All seven of these technologies are described later in this report.

The data gathered from this project will be supplied to all DOE sites that are participating, as well as any other site that might be interested in this type of treatment. All information will also be transferred to EM's Office of Environmental Restoration (EM-40) for their evaluation and potential incorporation into their restoration activities. All test results will be made available to the public, the UNR library system, and anyone involved in the restoration of contaminated sites. Discussions are also being held with personnel from Australia.

## For further information, please contact:

**S. P. (John) Mathur**  
Program Manager  
U.S. Department of Energy  
(301) 903-7922

**Mike G. Lewis**  
Project Manager  
MSE, Inc.  
(406) 494-7443

## 1.2 HEAVY METALS SEPARATION TECHNOLOGIES

### The Air-Sparged Hydroclone

The Air-sparged hydroclone (ASH) flotation is a new particle separation technology that has been under development at the University of Utah and Advanced Processing Technologies, Inc. This technology combines froth flotation principles with the flow characteristics of a hydroclone, such that the ASH system can perform flotation separations in less than a second. This feature provides the ASH with a high processing capacity, 100-600 times greater than the capacity of conventional flotation or columns.

The ASH consists of two concentric right- vertical tubes, a conventional cyclone header at the top, and a froth pedestal at the bottom (Figure 1.2a). The inner tube has a porous wall (plastic, ceramic, or stainless steel) through which air is injected. The outer non- porous tube simply serves as an air jacket to

provide for even distribution of air through the porous inner tube. The slurry is fed tangentially through the conventional cyclone header to develop a swirl flow of a certain thickness in the radial direction (called the swirl layer thickness) adjacent to the porous wall, leaving an empty air core centered on the axis of the ASH. This swirl flow shears the injected air to produce a high concentration of small bubbles. Hydrophobic particles in the slurry collide with these bubbles, and after attachment, lose some of their tangential velocity and centrifugal momentum, and are transported radially into a froth phase that forms at the surface of the air core on the cyclone axis. The froth phase is stabilized and constrained by a froth pedestal at the underflow and thus moves towards the vortex finder of the cyclone header and is discharged as an underflow product through the annular opening between the inner porous wall and the froth pedestal.

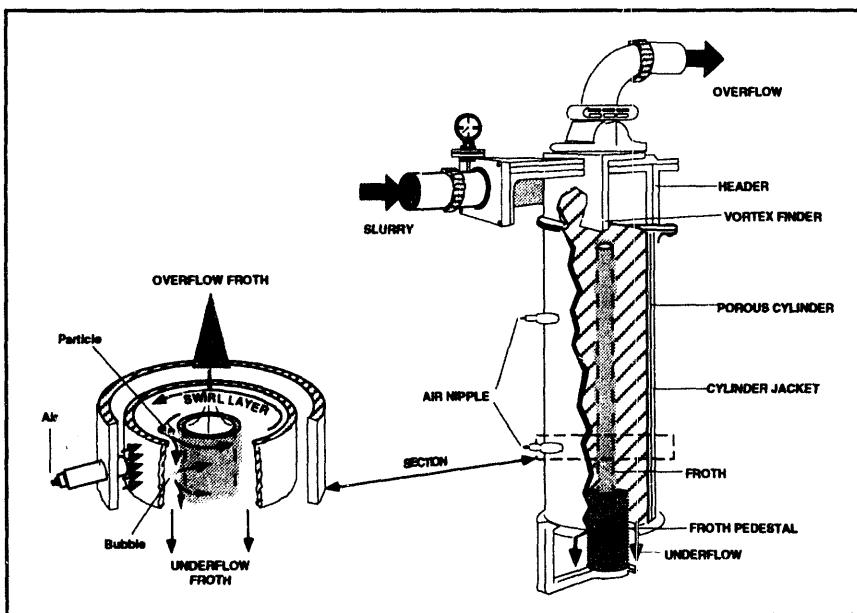


Figure 1.2a. Air-sparged Hydroclone Technology.

### The Campbell Centrifugal Jig

The Campbell Centrifugal Jig (CCJ) is a patented new technology developed by TransMar, Inc., of Spokane, Washington, to separate fine, heavy mineral particles from gangue material (i.e. waste). The CCJ is a combination of two widely used methods of dense particle separation: jiggling and centrifuging. The CCJ combines the effectiveness of continuous flow and pul-

sating bed of the standard mineral jig with the high "g" forces of the centrifuge. The manner in which this is accomplished is shown in Figure 1.2b, a schematic showing major elements and flow patterns in the CCJ. The slurry material enters the CCJ through the hollow shaft and is thrown radially outward by the vanes on the diffuser plate to impact on the batter plate, which distributes it over the rotating screen. Pulse blocks rotate with the hutch and screen, and each time they align with one of the inlet ports, the pulse blocks provide a high pressure intensity water pulse to the outside of the screen, keeping the material fluidized. Heavy particles migrate through the bed and screen and enter the hutch to be recovered through the discharge ports as concentrate. Lighter particles are flushed downward across the jig bed and become tailings.

The Heavy Metals Contaminated Soil Project Phase 1 testing indicated that the CCJ can reliably remove from 70 to over 90 percent of the contaminant from gangue material (to the extent that bismuth is an adequate surrogate for plutonium oxide). In addition, it can reduce the contaminated volume by factors from

close to 100 to over 600 in a single pass through the system; standard gravity separation uses several jigs in a series. It was also demonstrated that the CCJ can successfully operate on very small quantities of feed (1,500 to 2,000 pounds) and for short durations (30 minutes or less).

### Centrifugal Gravity Concentrator

The Centrifugal Gravity Concentrator utilizes the principle of hindered settling combined with centrifugal action (Figure 1.2c). This is made possible with a proprietary mechanism of a water-jacketed perforated cone fed through a hollow shaft-hydraulic device. Gravity concentration devices, like the Centrifugal Gravity Concentrator, depend upon differences in particle size, particle specific gravity, or both (i.e. particle mass) for their effectiveness.

The UNR unit is a centrifugal bowl concentrator with a water jacket around the bowl, essentially a modified centrifuge. Feed slurry enters the rotating ribbed bowl where heavier particles are trapped between the ribs. Compaction of the material between the ribs is

prevented by injecting water through holes in the bowl. The water fluidizes the bed and allows heavier particles to continuously displace lighter particles. The water addition is the key to the performance of the Centrifugal Gravity Concentrator. The degree of fluidization controls the effectiveness of separation.

The Centrifugal Gravity Concentrator used in these experiments is a

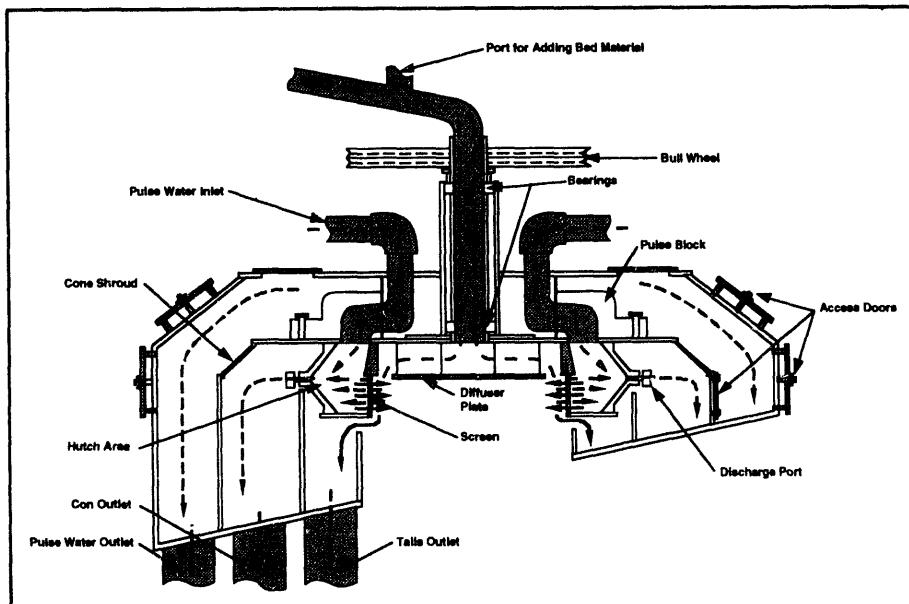


Figure 1.2b. Schematic of the Campbell Centrifugal Jig Technology.

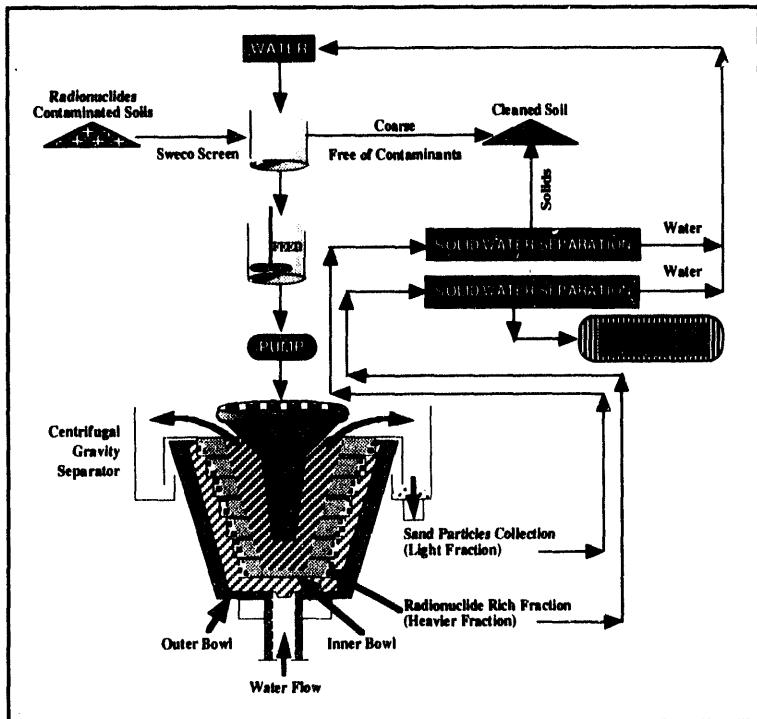


Figure 1.2c. Centrifugal Gravity Separation Technology.

3-inch stainless steel lab model. A motorized force of 60g is exerted on the medium. The concentrator handles either coarse or fine feed at 25% solids. The model's dimensions are 24 inches in length, 16 inches in width, and 20 inches in height.

### Tall Column Flotation

The effectiveness of mechanical flotation devices decreases in ultra-fine particle size largely because of the large bubble size (as large as 1mm) and turbulent conditions present in the cell. The column flotation technology has been very popular and effective recently in the flotation of ultra-fine particles.

Considering the fact that a large fraction of radionuclides is present in the 38 micron size soil and its concentration is in parts per billion (ppb) range, it is conceivable that a combination of conditions such as fine bubble size (30-60 microns), quiescent conditions, and froth drainage mechanism prevalent in the column will result in selective separation of discrete ultra-fine radionuclides from contaminated soil.

The column flotation is a tall device, having at least a length-to-diameter ratio of 10:1 (Figure 1.2d). The reagentized slurry is fed at the upper portion of the column and travels downward.

The hydrophobic particles attach to the rising stream of fine bubbles generated at the bottom of the column. The swarm of air bubble-laden particles are further washed at the top of the column to minimize the entrainment of unwanted material (in this case, clean soil). The radionuclide-enriched soil fraction

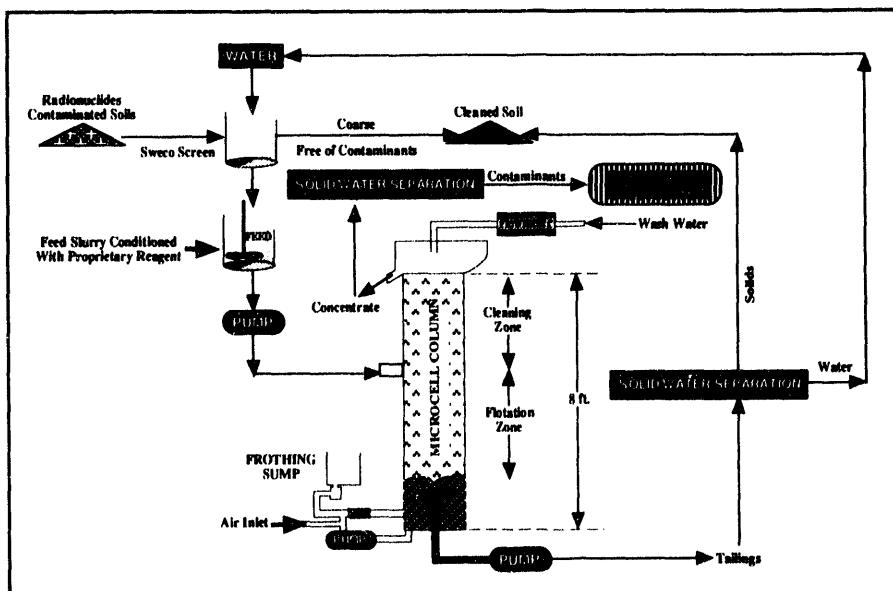


Figure 1.2d. Column Flotation Technology.

overflows at the top of the column and hydrophilic clean soil unattached to bubbles is collected at the bottom.

The UNR column is made of plexiglass in four sections, measuring 2 inches in diameter and 10 feet tall. An external bubble generator system is attached to it at the bottom, which consists of an in-line mixer and a variable speed centrifugal pump. The level control system consists of overflow tubing, a sandgate valve, and two flow meters (one for wash water and the other for air addition). The automatic level control system is made up of a pressure transducer, controller, and tailings discharge pump.

### Automated Mechanical Flotation (Denver Unit)

Flotation is a physico-chemical process in which one mineral constituent can selectively be separated from another on the basis of surface properties. This is achieved by adding controlled additions of chemical reagents at a predetermined pH, thereby selectively altering the surface characteristics of radionuclide enriched particulates. This treatment renders soil particles contaminated with radionuclides as hydrophobic (water repellent). Phase separation is then followed by passing air through reagentized slurry. Air bubbles selectively attach to radionuclide-enriched soil particles and are levitated to the surface in the form of froth. The separation of soil particles contaminated with radionuclides thus renders the remaining soil clean.

The Automated Mechanical Cell (Figure 1.2e), developed by UNR, is a modification of the Denver D-12 laboratory machine that incorporates a 120 VAC adjustable automated froth removal system and a controller to maintain constant pulp-froth interface. The modification to the Denver unit is in the mounting of the main shaft. The unit has been outfitted with a 90-degree pivoting elbow with a keyed shaft allowing height adjustment and rotation of the unit into operating position. The unit has an adjustable speed motor with a two-blade froth removing paddle. Critical operational adjustments are made by 1) moving the motor housing laterally on the shaft to regulate clearance in the paddle-dam relationship without the need for any locking mechanism, and 2) moving the vertical collar pivot up or down to set the paddle depth into the froth. The froth collection system consists of a tapered bottom and inclined trough to collect heavy radionuclides. The pulp-froth interface level control is achieved by sensing the vertical position of a float in a sight glass by a proximity switch. The switch is connected to solenoid valves and flow regulators.

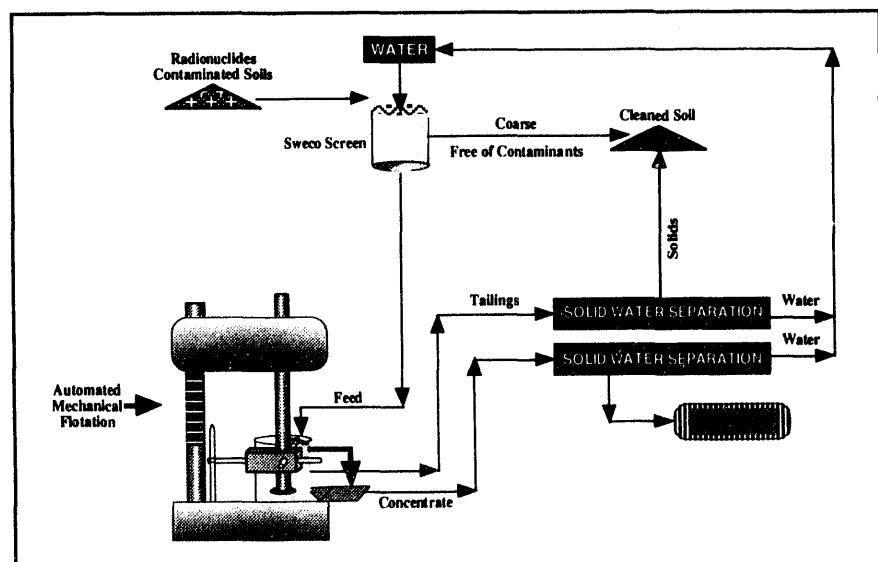


Figure 1.2e. Automated Mechanical Flow Technology.

## High Gradient Magnetic Separation

Los Alamos National Laboratory, in conjunction with its industrial partner Lockheed Environmental Systems and Technology Co., is exploring a promising new technique that could be used to remove radioactive contaminants from soils. The technique, high-gradient magnetic separation (HGMS), takes advantage of the fact that all actinide compounds are slightly magnetic. Much of the contaminated soil contains plutonium and uranium oxide particles; these slightly magnetic particles are attracted by very strong magnetic fields and thus can be separated from the mostly nonmagnetic soil. The availability of reliable superconducting magnets, which create very strong magnetic fields, makes HGMS an attractive method for extracting actinide contaminants. Preliminary experiments with magnetic surrogates and modeling of the process have yielded encouraging results. Contaminated soil samples from DOE sites are now being tested, and the partners are working to develop the process for full-scale site remediation.

To begin the HGMS process, a slurry is made by mixing contaminated soil with water. This slurry then flows through a chamber filled with a matrix that can be magnetized, such as steel wool (see Figure 1.2f). A superconducting magnet surrounding the chamber produces a magnetic field strong enough to cause the magnetic particles, including the actinides, to adhere to the matrix. After the batch of slurry has passed through the chamber, the magnetic field is removed and water flows through the matrix to flush out the radioactive particles. The residue is then concentrated and

packaged for proper storage or disposal, the waste and matrix are recycled, and the soil from the slurry is returned to the environment, if it is sufficiently decontaminated.

## The SEPOR System

The USNA SEPOR system is a commercially-available, bench-scale air separation technology being evaluated by the USNA to remove heavy metals from soils.

The system produces two effluent streams, one containing predominately smaller sized particles and referred to as the fine discharge, and the other containing predominately larger particles, referred to as the coarse discharge. It is the goal of the evaluation to concentrate most of the heavy metal in one of the effluent streams, so as to reduce the volume of contaminated soil requiring site removal.

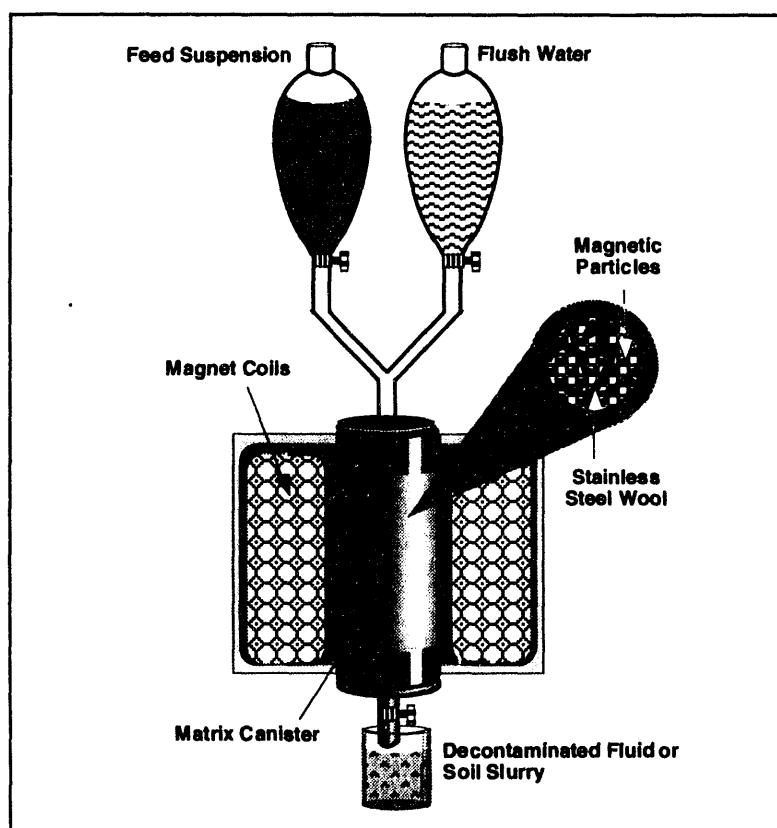


Figure 1.2f. High Gradient Magnetic Separation Technology.

The USNA SEPOR system uses a centrifugal force effect to achieve separation. A schematic of this system is shown in Figure 1.2g. The contaminated soil is fed into this system through a feed pipe, whereupon it then falls into a separating chamber. Separation is achieved through action of a centrifugal fan, which aerodynamically imparts a greater radial velocity to the larger size particles. The soil particles, which on average are larger than the heavy metal particles, move more rapidly to the separating chamber wall, where they then drop down and are collected as they

tem has a soil feed capacity of 800 lbs/hr. Feedrate of soil into the SEPOR is controlled by a volumetric screw-type feeder, and can be varied through a wide range.

Sieving of the effluent is being investigated to improve the concentrating effect of the process. Airborne particulate emission is also being studied through the use of an MIE real-time airborne particulate monitor. System design modifications are being implemented in order to minimize the release of airborne particles during testing, as well as minimize soil hangup inside the SEPOR system.

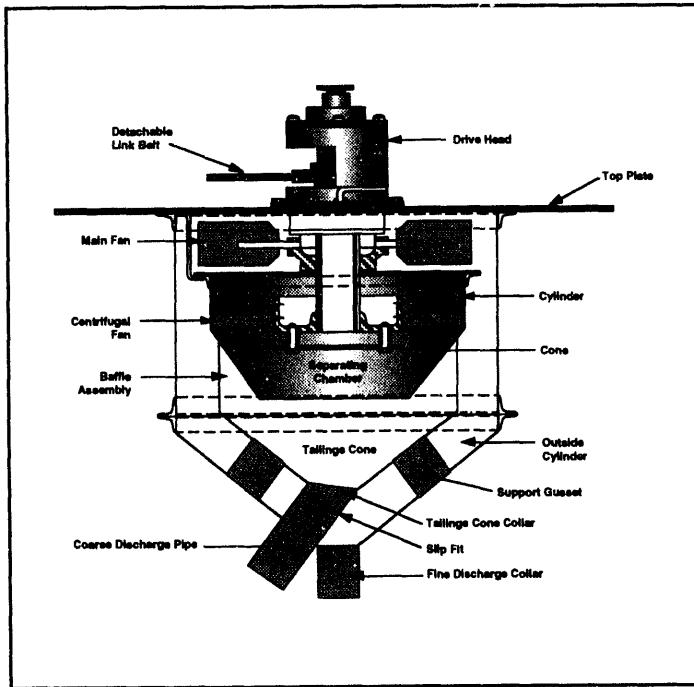


Figure 1.2g. SEPOR System.

exhaust through the discharge pipe. The smaller particles are carried upward by the air, which is being circulated through the chamber by the main fan. Some of the smaller particles reenter the separating chamber through baffles, which are located near the bottom of the separating chamber. Eventually most of the smaller sized particles drop through the fine discharge pipe. The USNA SEPOR system is a bench-scale system with an 18" diameter. The sys-

**For further information,  
please  
contact:**

**Dr. Manoranjan Misra**  
Professor of Chemical and Metallurgical Engineering  
University of Nevada at Reno  
(702) 784-4307

**Mike G. Lewis**  
Project Manager  
MSE, Inc.  
(406) 494-7443

## 1.3

## BIOMASS REMEDIATION SYSTEM

### TASK DESCRIPTION

The project goal is to demonstrate the feasibility of using plants (both terrestrial and aquatic) to remediate soils, sediments, and surface waters contaminated by heavy metals and radionuclides (see Figure 1.3). Feasibility will initially be evaluated by:

- 1) Procuring biomass samples from plants growing or cultivated on contaminated soils and waters, determining the accumulation of heavy metals/radionuclides in the plant biomass (relative to contaminated soil); and
- 2) Subjecting the bio-mass to the Ukrainian Fractionation Separation Technology (FST) to establish the distribution of the elements or isotopes of concern in the biomass. The objective of the FST process is to concentrate and separate the contaminants of concern from the bulk biomass and/or recover uncontaminated biomass fractions that could be more easily disposed of or used for other applications (fodder, etc.).

The technology will be tested initially using plant material grown on heavy metal contami-

nated soils in the area of the Silver Bow Creek Superfund site (near Butte, Montana) and on Berkeley Pit water. Other plant biomass specimens derived from contaminated DOE facilities or from other sites will also be subjected to testing and evaluation in the initial feasibility study.

A small, bench-scale FST system will be built and operated at a site in Butte, Montana. Following successful demonstration and evaluation of the bench-scale process system, a larger, field-scale, mobile FST system will be tested at a DOE demonstration site (to be selected).

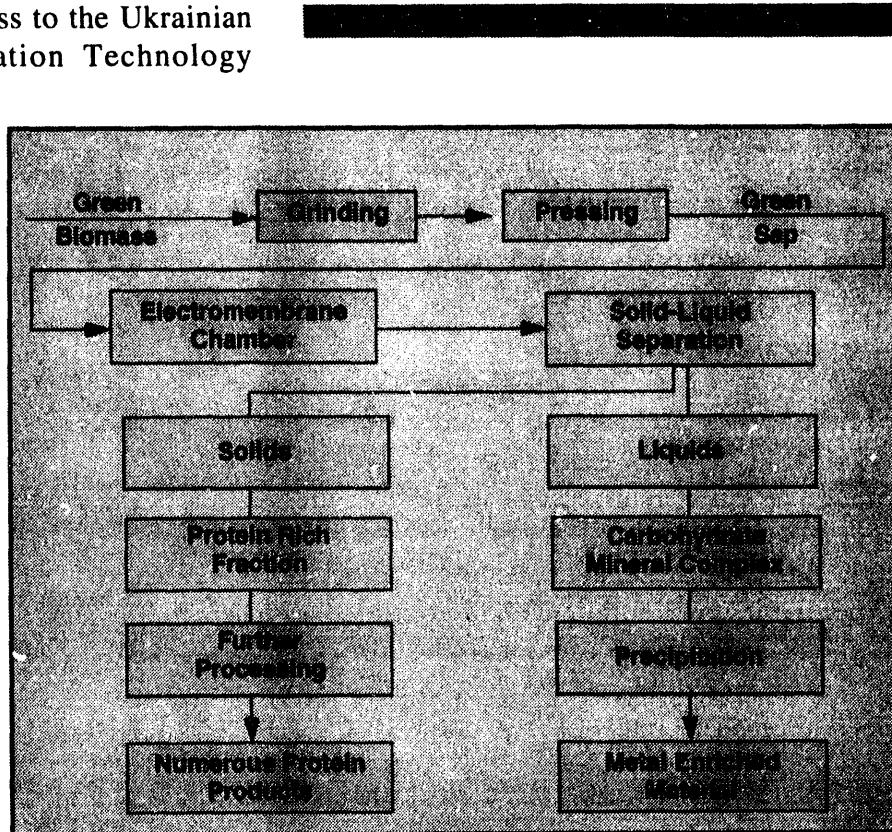


Figure 1.3. Fractionation Separation Technology Process for macrophyte remediation of contaminated soils.

## **TECHNOLOGY NEEDS**

Considerable heavy metal contamination exists in soils and groundwater across the DOE complex, and much of this contamination is of low concentration. For such low levels of contamination in a relatively large quantity of soil and water, removal and storage or remote treatment (such as incineration, for soil) become extremely expensive. The bioremediation technology proposed could be less expensive than soil removal and treatment given the real extent and topography of the sites under consideration, the problems associated with process-generated fugitive dust emission, and the investment of energy and money in the soil-moving or water-pumping and treatment processes. Moreover, in situ technology may receive regulatory acceptance more easily than ex situ treatments. Taking advantage of the natural ability of plants to take up metals is indeed an inexpensive and publicly appealing method by which remediation of low-level heavy-metal/radio-nuclide contamination can occur.

## **ACCOMPLISHMENTS**

Use of the FST to remove heavy metals from plants and to isolate useful materials from previously contaminated plants has already been demonstrated in the Ukraine. Data from the Ukraine and an initial literature review have confirmed that both aquatic and terrestrial plants accumulate radionuclides from water and soil. A draft test plan defining the sequence of experiments will be completed in October 1993. Tests are designed so that the results will allow evaluation of biomass processing technology for DOE environmental restoration needs.

Testing for the ability of the FST technology applied to soil remediation will be completed during December 1993. This demonstration will be executed near Butte, Montana, using the heavy metal fallout from a past smelting operation as a radionuclide surrogate. Metal-tolerant/accumulating native plant species, legumes and small grains will be used to determine the applicability of these biomass sources to these contaminants.

## **COLLABORATION/TECHNOLOGY TRANSFER**

MT International, a U.S. corporation, has established a joint venture agreement, American-Ukraine Biotech JV (AUB), with the Central Scientific Research Laboratory of Comprehensive Processing of Plant Raw Material of the Ukrainian Academy of Agrarian Sciences. The Ukrainian Academy of Agrarian Sciences and Berevetnik Scientific Research Institute have conducted large scale soil remediation, implementing a biomass processing system, near the radioactive Chernobyl site. American Ukraine Biotech JV will provide the laboratory scale system design and personnel necessary for operation. Additionally, AUB will design and demonstrate the pilot scale system. Technical support to assist in selecting appropriate plant species for demonstration tests and evaluating the potential of applying the technology to aquatic plants for phytoremediation of contaminated water is included in the AUB tasks.

**For further information, please  
contact:**

**Dr. Rashalee Levine**

Program Manager

U.S. Department of Energy

(301) 903-7920

**William Goldberg**

Project Manager

MSE, Inc.

(406) 494-7367

## 1.4

# THE MINIMUM ADDITIVE WASTE STABILIZATION PROGRAM

In the Minimum Additive Waste Stabilization (MAWS) program, actual waste streams are utilized as additive resources for vitrification, which may contain the basic components (glass formers and fluxes) for making a suitable glass or glassy slag. If too much glass former is present, then the melt viscosity or temperature will be too high for processing; while if there is too much flux, then the durability may suffer. Therefore, there are optimum combinations of these two important classes of constituents depending on the criteria required. The challenge is to combine these resources in such a way that minimizes the use of non-waste additives yet yields a processable and durable final waste form for disposal. The benefit to this approach is that the volume of the final waste form is minimized (waste loading maximized) since little or no additives are used and vitrification itself results in volume reduction through evaporation of water, combustion of organics, and compaction of the solids into a non-porous glass. This implies a significant reduction in disposal costs due to volume reduction alone, and minimizes future risks/costs due to the long term durability and leach resistance of glass.

This is accomplished by using integrated systems that are both cost-effective and produce an environmentally sound waste form for disposal. Individual component technologies may include:

- vitrification;
- thermal destruction;
- soil washing;
- gas scrubbing/filtration; and,
- ion-exchange wastewater treatment.

The particular combination of technologies will depend on the waste streams to be treated. At the heart of MAWS is vitrification technology, which incorporates all primary and secondary waste streams into a final, long-term, stabilized glass waste form. The integrated technology approach, and view of waste streams as resources, is innovative yet practical to cost effectively treat a broad range of DOE mixed and low-level wastes.

Vitrification has traditionally been used within the DOE Complex for treatment of low-volume, high-level radioactive wastes with low waste loading and high treatment cost. However, the economic attractiveness for treating large volumes of low-level/mixed waste (by maximizing waste loading) and the feasibility of production-scale processing have yet to be demonstrated. This program will demonstrate both the economics of total life-cycle cost savings, through increased waste loading and final waste volume reduction, and the production-scale feasibility of various vitrification technologies to treat large volumes of low-level/mixed waste through a synergistic approach. In addition, it will demonstrate the capability of producing a leach-resistant (long-term) waste form, with by-products such as clean water and soil for placement back into the environment, and an off-gas effluent that meets regulatory requirements (See Figure 1.4).

The vitrification process uses high temperatures (typically between 1100 and 3000°C) to chemically incorporate wastes into a glassy matrix. Vitrification is a process whereby a material is transformed at high temperatures

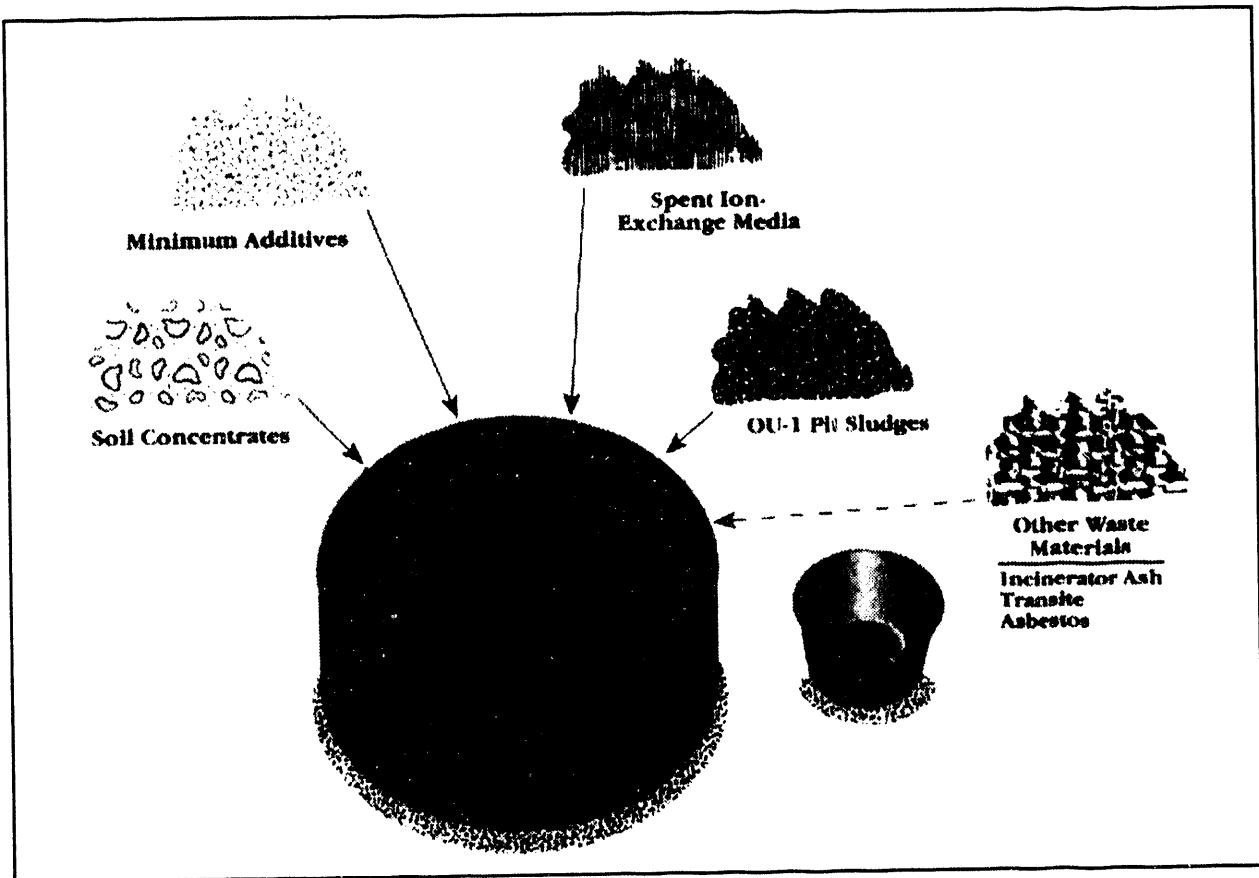


Figure 1.4. Minimum Additive Waste Stabilization.

into an amorphous liquid, which upon cooling and largely without crystallization becomes an amorphous solid. Crystalline phases may be either thermodynamically unstable or kinetically unable to form during the cooling down period. Either way, the resulting bulk solid has an unordered structure. A glass by definition is a completely amorphous solid, whereas a ceramic is largely crystalline with fused grain surfaces. In between these two extremes are a wide variety of glassy ceramics in which crystalline phases are dispersed throughout a glassy continuous phase. Such materials may include slags which incorporate various metal oxides. These waste forms are also under evaluation, and show promise for long term stability and leach resistance.

Glass or glassy ceramic (slag) waste forms produced by vitrification are unique in that

they can easily accommodate a wide range of metal oxides into their structure and yet produce a stable and durable material. It is precisely the amorphous structure of the glass phase which allows this incorporation of many constituents, and why vitrification was chosen as the technology upon which MAWS is based. The waste is not merely encapsulated, but actually becomes part of the glass structure.

## TASK DESCRIPTION

The focus of this study area is on the vitrification and associated supporting equipment to be used in the MAWS program, with a view toward the feasibility of producing an *environmentally-sound and durable final waste*

form. The objective is to assess the current state of vitrification technology and choose those technologies for further radioactive waste treatment development that have a proven record of accomplishment, reliability, and commercialization in the private sector. Once these assessments have been completed, a long range plan needs to be developed that will provide costs and strategies to bring these technologies on-line for radioactive waste treatment. It is initially envisioned to assess two technologies at the bench scale, and then choose one for initial further development at the pilot stage. A plasma technology has been identified as one likely melter configuration which is now being assessed at the bench scale.

The comprehensive plan to implement/coordinate additional MAWS developmental work needed for equipment evaluation was prepared and completed in October 1993. This plan was prepared by MSE, Inc. with guidance from DOE. MSE is identifying potential entities (industries, academia, and the National Laboratories) for their specific expertise to conduct work in the following technology areas:

- Materials science studies to determine the matrix of test materials.
- Identification and assessment of promising technologies as to MAWS applicability, their maturity stage, and availability of equipment for testing. This includes recommendation of a few of the most promising for further development.
- Identification of testing facilities (rad/non-rad) for capabilities.
- Waste product long-term durability testing to validate the waste form quality.

- Preliminary life-cycle cost estimation.
- Cost and overall schedule for the entire package.

MSE will solicit input from appropriate entities to participate in various parts of the MAWS program, review their proposals, and make recommendations in the area of promising equipment to be developed. MSE will integrate the recommended proposals and propose an overall plan and schedule to initiate work in FY94.

Work to this point has focused almost entirely on a low temperature joule heated melter system. In other variations of vitrification technology, a plasma or microwave system may be employed as a high temperature process operating between 1800 to 2600°C. In such a system a more viscous glass or slag can be produced with fewer limitations on metals content or organics in the waste streams chosen. As before, the cost effectiveness of the technology compared to other technologies will be the main driver along with production of a stable, durable final waste form.

Initial evaluation tests are currently underway using the Plasma Centrifugal Furnace (PCF) technology available from ReTech, Inc. These tests are being coordinated by MSE, Inc. In these tests, metal loadings up to 70 % are anticipated which will produce a durable final slag waste form. Produced wastes will be carefully evaluated by Toxicity Characteristic Leach Procedure (TCLP) and Product Consistency Test (PCT) determinations. In addition, off-gas data will be collected and assessed to determine the effectiveness of the technology system as a whole for treating waste and posing no further threat to the environment.

Pending the results of the bench scale testing work and the direction chosen, future devel-

opment work may be required to begin the scale-up to a commercial sized vitrification system which can be incorporated into the overall MAWS concept. This future pilot stage should probably be site specific for a particular set of waste streams that can best use this technology.

## TECHNOLOGY NEEDS

To compliment the compositional envelope work, several vitrification technologies need to be evaluated to be able to handle waste streams not suited to the low-temperature joule-heated melter. Much of this development work can be done concurrently with the compositional development work by using a mix of actual and simulated waste streams in test work. The real waste streams will serve to focus the efforts on real problems while the simulated waste streams will allow maximum information to be derived from compositional variation. For easy transfer to the many potential waste sites, assessments as to the maturity of the specific technology need to be done. In many cases, this may require both bench scale evaluations as well as pilot plant operations to minimize risks and potential problems when the technology becomes commercial.

It is desired to practice the MAWS program with various technologies to fulfill a wide range of treatment needs. Technologies to compliment the current low temperature Joule heated furnace configuration are needed particularly for wastes with a high metals content. One example of such technology is the plasma centrifugal furnace which needs to be proven in its ability to completely oxidize the metals to arrive at a stable and durable waste form. The results should give an initial indi-

cation of the capability of plasma utilizing the MAWS concept.

## ACCOMPLISHMENTS

- A low temperature Joule heated melter has been developed and radioactive feeds tested at the bench scale. The melter has successfully processed high fluorine wastes to produce quality glasses.
- The procurement package for ReTech to do the plasma testing at Ukiah, CA has been completed. It was submitted to PETC for approval and has been issued to ReTech.
- Provisions have been made for off-gas sampling during the tests to provide data on problem volatiles.
- Initial tests have indicated that the equipment is capable of melting mixed high metal containing wastes; complete metal oxidation has been achieved in a test with up to 70 % carbon/stainless steel. More work is being done to optimize furnace operational parameters and explore compositional variation.
- A draft of the long range plan has been put together which identifies both single and two stage thermal treatment options and fast track versus normal development options.

## **COLLABORATION/TECHNOLOGY TRANSFER**

Current technology development of the PCF is being coordinated through MSE, Inc. at Ritech in Ukiah, CA. Laboratory evaluation of waste forms for this work is subcontracted to Argonne National Laboratory (ANL). The long range plan for high temperature technologies is being developed by MSE, Inc. with consideration given to conducting the test program at qualified university or industry participants.

**For further information, please  
contact:**

**Grace Ordaz**  
Program Manager  
U.S. Department of Energy  
(301) 903-7440

**Dan Battleson**  
Project Manager  
MSE, Inc.  
(406) 494-7412

**TASK DESCRIPTION**

The Resource Recovery Project (RRP) will evaluate, test and demonstrate technologies, at pilot scale, for reclamation of both surface and groundwater from dilute heavy metal aqueous solutions (see Figure 1.5). The project will emphasize recovery of valuable mineral resources, including heavy and/or precious metals, as well as industrial minerals. Economic analyses of each technology and the resources recovered will be used to project resource recovery and/or remediation costs for similar DOE and industrial sites using similar technologies. The project will focus on resource conservation and end-use applications of the recovered resources by maximizing resource utilization and minimizing non-useable byproducts. Resource utilization will address industrial, commercial, municipal/governmental, agricultural and recreational uses of water, metals, and other resources. Economic and technical feasibility analyses of each technology demonstrated will be conducted. The analyses will include potential revenues from sales of water and mineral resources. Cost/benefit analyses will be an integral part of the project. The data obtained will demonstrate, at pilot scale, which technologies are the most effective at recovering resources and remediating contaminated waters, and which are the most cost efficient, including the cost realized from resource utilization. The data gathered will allow for the timely and cost-effective selection of appropriate reclamation technologies at various sites throughout the DOE Complex. Through technology transfer, the data generated can also be applied to other Federal agency (particularly, the Bureau of Mines) and private-sector sites.



Figure 1.5. The Berkeley Pit test bed for the Resource Recovery Project.

**TECHNOLOGY NEEDS**

Heavy metal-contaminated water is a nationwide problem. Heavy metals pose a significant threat to both human health and safety and aquatic environments. Some metals are neurotoxicants (lead, mercury, cadmium), while others form potentially carcinogenic organometallics.

There are currently more than 300,000 abandoned hard rock mines in the United States that pose a threat to health and the environment due to acid mine drainage. Runoff containing acids, metals, and chemicals from abandoned mine sites has contaminated more than 12,000 miles of rivers and streams and more than 180,000 lakes and reservoirs.

Surface and groundwater contamination by heavy metals is a problem at numerous sites within the United States. Over 75% of all sites on the National Priorities List (Superfund) have surface or groundwater contamination.

DOE has identified heavy metal contaminated ground and surface water at numerous facilities, while DoD has identified heavy metal contamination at over 900 Army installations, and contamination from heavy metal-bearing wastewater from 93 industrial-type DoD installations.

## ACCOMPLISHMENTS

- Completed legal and regulatory issues report.
- Issued Berkeley Pit Water Quality characterization interim report.
- Established technology selection criteria and formed technology selection committee.
- Currently identifying markets for clean water and recovered metals/minerals.
- Initiated government and industry partnerships for technology implementation.
- Began modification of existing facility to house demonstrations.
- Plan to issue Request for Proposal for FY94 technology demonstrations in 1994.
- Selection of three to five technologies for demonstration during FY94 will be made during the second quarter of FY94, with demonstrations beginning during the third quarter of FY94.

## COLLABORATION/TECHNOLOGY TRANSFER

The RRP is in active partnership with many public and private sector interests. Public sector participants include DOE, the State of Montana, EPA, WGA, Montana Bureau of Mines and Geology, Colorado Center for Environmental Management, National Institutes of Water Resources, Montana College of Mineral Science and Technology (Montana Tech), and American Alliance for Environment and Trade. Private sector participants include industrial mining and smelting companies, technology providers from throughout the United States, Superfund responsible parties, environmental public interest groups, and others.

The RRP prepared a Business Plan to be used on specific technologies not yet commercialized. The plan is designed to assist and facilitate technical and business alliances between technology providers, remedial problem-holders, venture capitalists, and other financial institutions. These government/industry alliances and partnerships play a key role in the national effort to reclaim contaminated water and recover those same "contaminants" as marketable industrial/commercial resources.

### For further information, please contact:

**S. P. (John) Mathur**  
Program Manager  
U. S. Department of Energy  
(301) 903-7922

**Mike G. Lewis**  
Project Manager  
MSE, Inc.  
(406) 494-7443

## 1.6

## RESOURCE RECOVERY PROJECT TECHNOLOGY DEMONSTRATIONS

### **Electrochemical Design Associates - Rotating Cylinder Electrodes and Electrochemical Ion Exchange Modules.**

Metals are electrically deposited directly from Berkeley Pit water in a series of stages with copper, zinc, and iron being primary targets (other trace metals will be removed also). Rotating cylinder electrode (RCE) cells will be used at each stage to increase mass transfer rates during direct electro-deposition of metal powders. Final removal at each stage is to be done with electrochemical ion exchange (EIX), which is normal ion exchange except that the resin is incorporated in an electrode. Under a potential, the exchangeable heavy-metal solute is accelerated in its transport to the resin. EIX is used as an electrochemical polishing process after each RCE step for each metal removal stage. The current is periodically reversed to strip the resin.

### **IBC Advanced Technologies, Inc. - Highly Selective Molecular Recognition Technology using "Superlig" ligand removal.**

This technology will use IBC Advanced Technologies, Inc.'s (IBC) highly selective proprietary ion exchange media (Superlig) in fixed bed columns to selectively extract sequentially, iron(III), copper, aluminum, zinc, iron(II), manganese, and a mixture of other resources, excluding the alkali and alkaline earth metals. The selectivity is based on IBC's unique media that combines molecular recognition technology (crown ethers and other crown-shaped organic molecules) tailored to each metal ion to be extracted with stable support media.

### **Vail Research and Technology Corporation and Pulsed Power Technologies, Inc. - using pulsed electrical discharges.**

This technology is based on repetitive high energy electrical pulses from a charged capacitor bank discharged between two electrodes immersed in Berkeley Pit water to break down hazardous materials into their elemental components. An existing pulsed plasma discharge system will be used. The process of discharging high levels of electrical energy into Berkeley Pit water is expected to produce residual materials that will be marketable to copper and zinc smelters, recycling facilities, agricultural product manufacturers, and other industrial firms. A centrifuge will be used to perform a solid/liquid separation for product recovery.

### **E-REM, Inc. - Contaminant concentration using clathrate formation.**

This is a demonstration of a desalinization technology aimed at making clean water and a concentrated sulfate solution; this is analogous to getting drinking water and brine bottoms from a desalinization plant. However, instead of precipitating salts, this technology will remove water as a clathrate. By bubbling gas at a given temperature and pressure through Berkeley Pit water, clathrate crystals (similar to ice crystals) are formed and can be removed. These crystals should contain only the working gas and water and leave the contaminants behind. By changing the temperature and pressure, the clathrate crystals break down, and the working gas and water can be recovered separately. The concentrated Pit water is then fed to a cleanup process.

**ChromatoChem, Inc., and International Technology Corporation - Solid-Phase Extraction by chelating agents.**

This demonstration will focus on the unique aspect of ChromatoChem's (CCI's) Solid Phase Extraction (SPE) absorbent. CCI binds long hydrophilic polyethylene glycol (PEG) molecules to the surface of chromatographic silica and binds chelating agents to the terminus of the PEG molecule. These molecules extend slightly away from the surface allowing for kinetics faster than typical ion exchange approaches. A standard cycle includes a loading phase where metals are bound by the chelating groups, an elution phase where dilute sulfuric acid solution is pumped through and protons displace the metal ions, and a recycle phase where a dilute basic solution is pumped through to generate the column. The metals therefore are sequestered in metal sulfate brine solutions where they can be marketed to the mineral processing industry.

At a minimum, aluminum, zinc, copper, and manganese will be recovered as sulfate brines. The RRP and CCI are considering options to recover iron and sulfate as well.

**For further information, please contact:**

**S. P. (John) Mathur**  
Program Manager  
U.S. Department of Energy  
(301) 903-7922

**Mike G. Lewis**  
Project Manager  
MSE, Inc.  
(406) 494-7443

**TASK DESCRIPTION**

This project is part of OTD's Buried Waste Integrated Demonstration, and is demonstrating the applicability of the Plasma PACT system for treating mixed (hazardous and radioactive) wastes and contaminated soil into an extremely durable waste form for disposal (see Figure 1.7). The PACT system is a rotating hearth plasma torch technology used for the refining of titanium and is now being developed for treatment of hazardous and mixed wastes and contaminated soils. The PACT has been demonstrated to be a very all-consuming waste treatment process during past testing for the EPA, DOE, and DoD. In the PACT system, waste is fed to a rotating hearth such that the waste and molten material are held to the side through centrifugal force. During the rotation, the waste moves through

plasma generated by a torch that does not rotate. To remove the molten material from the PACT, the rotation of the hearth is slowed and the slag flows through a central bottom opening.

The PACT has a nominal feed rate of over 300 lb/hr of buried waste-type feeds and soil. However, this technology should be scalable to larger capabilities using multiple plasma torches and larger hearth sizes. The feed system of the current melter is capable of feeding objects as large as 4 inches in diameter. The current system can handle limited quantities of hazardous (non-radioactive) materials. The processing of radioactive materials is being planned at other locations. No radioactive material will be processed at WETO.

The technology has application to the treatment and vitrification of hazardous, radioactive (both low-level and transuranic (TRU)), mixed wastes, and contaminated soils. This includes buried waste types of debris. These types of buried and stored waste are found at all DOE and DoD sites.

Successful implementation of the PACT system will render hazardous and

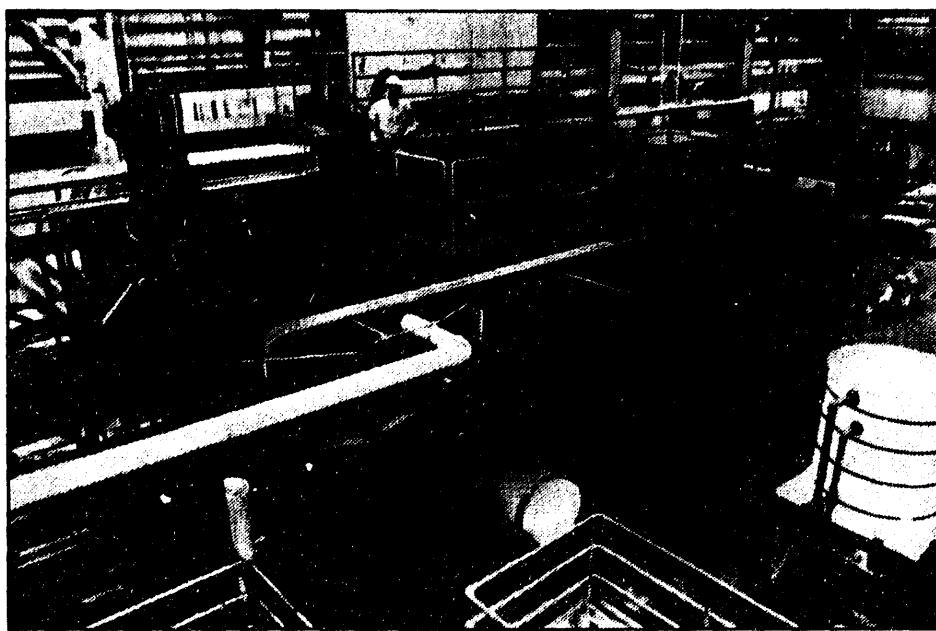


Figure 1.7. Retech's PACT system at the MSE test facility, Butte, Mt.

radioactive wastes and soils into a highly durable, glassy slag, with hazardous inorganic waste components being vitrified and stabilized into the slag. Reduced off-gas flows, high organic destruction efficiency, high waste volume reduction, and the ability to treat almost any type of waste in a single step process are significant advantages of the plasma process.

## TECHNOLOGY NEEDS

A treatment technology is needed that can handle a wide variety of waste mixtures (radioactive and non-radioactive), significantly reduce the waste volume, and provide a stable, long-lasting, final waste form.

## ACCOMPLISHMENTS

The operating envelop, operating procedures, and process rate of the PACT has been established for feeds processed to date (mainly INEL soil).

The first test provided a shakedown of the PACT equipment and a reference base (known composition) for future test matrix comparisons. Three other tests involved surrogate waste (INEL soil) spiked with ceric oxide (a plutonium surrogate). Preliminary results of the mass balance from the three tests indicated that less than 0.05 percent of the cerium surrogate was volatilized into the off-gas treatment system. It appears that 99.95% of the plutonium surrogate was retained in the final vitreous waste form. During the fall of 1993, extended duration tests were completed. Since plasma testing began in 1989, approximately 115,000 pounds of material have been processed, and approximately 1,000 hours of torch hours have been achieved.

## COLLABORATION/TECHNOLOGY TRANSFER

This furnace has been developed through an industrial partnership with MSE, Inc., DOE and Retech, Inc.

For further information, please contact:

**Jeff Ruffner**  
Project Manager  
MSE, Inc.  
(406) 494-7412

**TASK DESCRIPTION**

This project is part of OTD's Buried Waste Integrated Demonstration, and involves the demonstration and performance evaluation of the Plasma Hearth Process (PHP), a fixed hearth plasma arc treatment technology for the treatment of mixed (radioactive hazardous) wastes and soil to produce a durable waste form for disposal (see Figure 1.8).

This is not new technology, rather an application of an existing and commercially-available technology that has been used for many years for metals processing. Mixed waste treatment in a PHP furnace has several potential benefits, including:

- efficacy of organic destruction;
- versatility of application;
- a high-integrity vitrified final waste form that reduces leachability of both hazardous and radioactive contaminates; and
- waste volume reduction.

The PHP can process a wide variety of waste types including paper, cloth, plastics, metal, glass, concrete, soil, and sludge.

Performance testing with simulated wastes has been conducted in a pilot-scale PHP facility (3-4 barrels of waste per hour). A new generation PHP is being constructed by the Mixed Waste Integrated Program for further testing.

The nearly completed pilot-scale PHP unit is expected to process a nominal 3-4 drums/hr (130 to 550 lb/hr) of buried waste type feeds and soil. However, this technology should be scalable to larger capabilities using multiple plasma torches and larger hearth sizes. The feed system of the current melter is capable of feeding objects as large as a 35-gallon drum. A full-scale system would be capable of feeding objects larger than a 55-gallon drum. The current system can handle limited quantities of hazardous (non-radioactive) materials. The processing of radioactive materials is being planned.

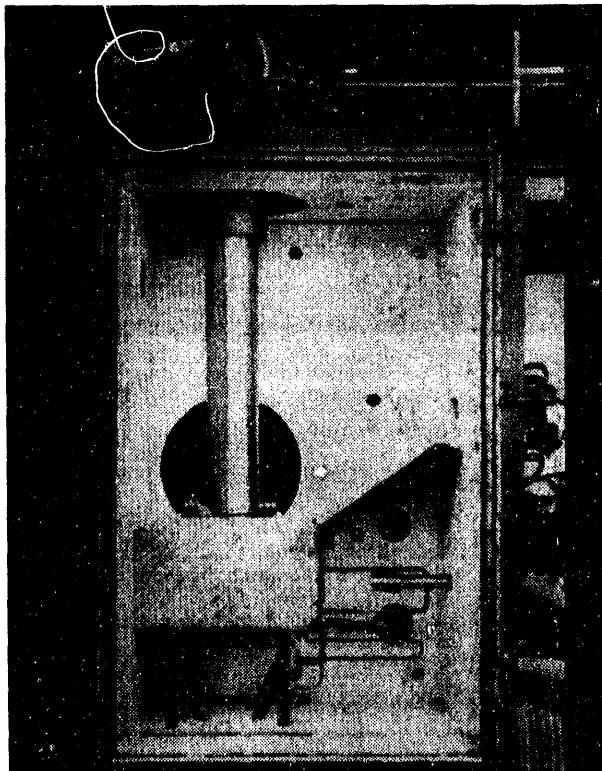


Figure 1.8. Fixed hearth and plasma torch at ReTech test facility.

The technology has application to the treatment and vitrification of hazardous, radioactive (both low-level and TRU), mixed wastes, and contaminated soils. These types of wastes are found buried or stored at DOE sites across the Complex.

A high-temperature plasma technology is particularly effective in the treatment of mixed wastes. Advantages of plasma treatment include:

- high efficiency destruction of organics;
- separation of metal from slag in the molten state, with TRU components partitioning to the slag phase;
- encapsulation of heavy metals and radionuclides in the final waste matrix;
- high-integrity, vitrified final waste form;
- improved criticality control;
- maximum volume reduction;
- smaller off-gas rates minimize particulate entrainment and carryover;
- higher energy density and smaller gas rates allow smaller process equipment;
- one-step treatment process (no pre- or post-treatment required); and
- capability to process many waste types.

## TECHNOLOGY NEEDS

A treatment technology is needed that can handle a wide variety of waste mixtures (radioactive and non-radioactive), significantly reduce the waste volume, and provide a stable, long-lasting, final waste form.

## ACCOMPLISHMENTS

A total of six performance tests has been conducted. Simulated waste materials consisted of mixed metals (ductile iron, cast iron, steel, aluminum, copper, and brass), metal oxide sludge, combustible solids (paper, polyethylene and polyethylene terephthalate, cloth, wood, rubber, etc.), and a combustible sludge. All waste materials were contained in a soil matrix, simulating retrieved waste. Each test consisted of feeding two 30-gallon drums containing a simulated waste.

The test series demonstrated the PHP can process a range of material types and compositions with no pretreatment.

The tests demonstrated successful processing of all waste categories; processed at a rate of 130 to 550 lbs/hr; demonstrated a thorough processing of combustibles, noncombustibles, and mixtures of both; and demonstrated the production of a high integrity final product in a single processing step. The test series also demonstrated effective destruction (greater than 99.99%) of organics; production of a highly durable and leach-resistant (properties comparable to glass) vitreous slag; and formation of two distinctly separate phases (metal and slag) in the molten pool.

## **COLLABORATION/TECHNOLOGY TRANSFER**

The PHP evaluation is being conducted with Science Applications International Corporation (SAIC) and ReTech, Inc. of Ukiah CA. SAIC is planning and conducting the testing at the Retech facility in Ukiah, CA. Planning for radioactive testing is underway.

**For further information,  
please contact:**

**Jeff Ruffner**  
Project Manager  
MSE, Inc.  
(406) 494-7412

## 1.9 FIXED HEARTH PLASMA ARC TREATMENT PROCESS

### TASK DESCRIPTION

The Mixed Waste Integrated Program (MWIP) is investigating fixed hearth plasma arc treatment of low-level mixed wastes. The fixed hearth plasma arc thermal treatment unit utilizes a DC-arc generated in a gas flowing between two electrodes. For solid materials, one electrode is the torch, while the other is the material being treated. Energy is resistively dissipated in the arc in the form of heat and light as the electric current flows through the gas between the electrodes. Joule (resistance) heating generates plasma temperatures in the gas (on the order of thousands of degrees Centigrade), which directly heats the wastes in the fixed hearth thermal treatment unit. Organics are destroyed, while metals and inorganics are melted. A vitrified (glassy) waste form is the final product of the process.

Plasma arc thermal treatment technology is characterized by high-efficiency destruction of organics, encapsulation of heavy metals and radionuclides in the vitrified final waste matrix, maximum reduction of waste volume, low off-gas rates, and the capability of processing many waste types in a single-step process.

Under plasma arc technology development and application projects, representative surrogate waste streams will be treated in a plasma arc furnace to determine the applicability of the technology and any unique processing requirements. Surrogates will initially not contain radioactive components. Partitioning of radionuclide surrogates will be determined, and a design for a second generation plasma arc furnace which will safely treat mixed low level (radioactive) wastes will be developed

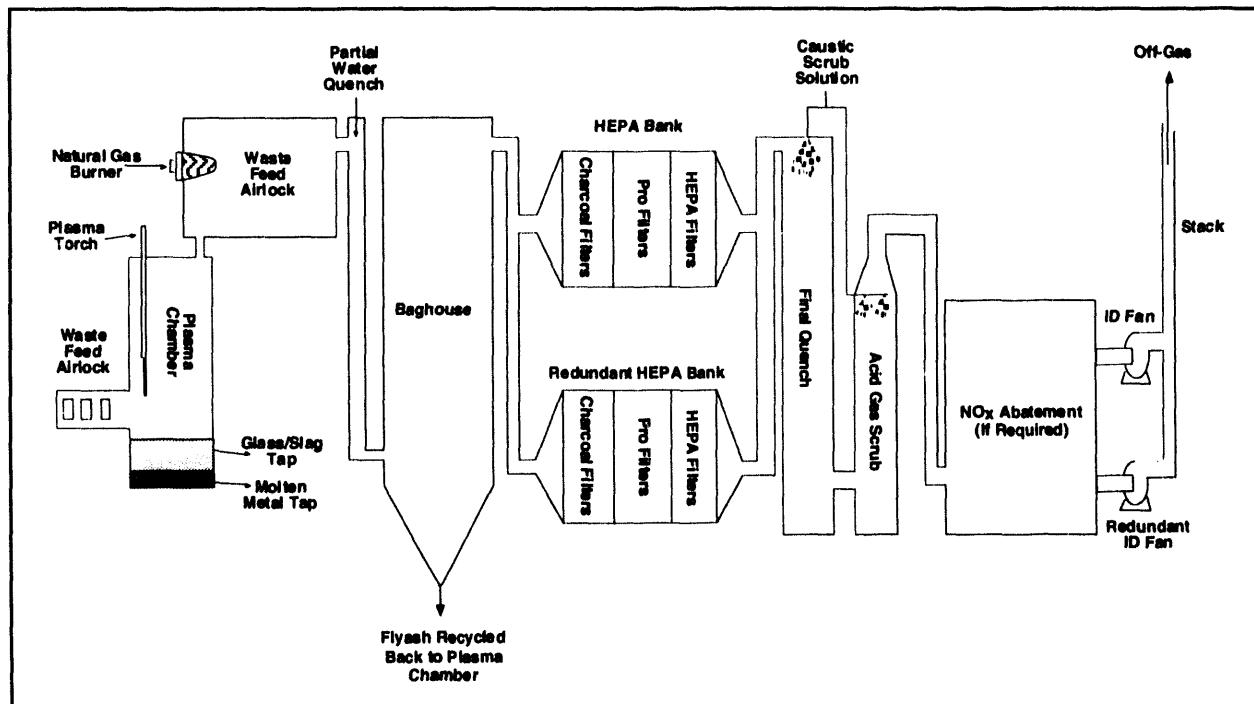


Figure 1.9. Plasma Hearth Process Prototype Design.

and tested. Waste stream characteristics which are required for processing will be determined, and the project staff will work with regulatory entities to determine the minimal characterization parameters required to meet regulatory requirements while ensuring process safety and effectiveness. Representative final (vitrified) waste forms produced by the process will be evaluated for their performance with respect to leachability, mechanical strength, integrity, and other parameters which will be determined under the project (see Figure 1.9).

## TECHNOLOGY NEEDS

Waste streams under the responsibility of DOE are heterogeneous and, as a result of the conditions under which the waste streams were historically generated, are poorly characterized. Detailed characterization of these wastes would incur significant costs. Technologies are needed, therefore, that can treat wastes, meet permit requirements, and satisfy process monitoring needs, with minimal waste stream (feedstock) characterization and segregation requirements. Further, treatment technologies are needed that dramatically reduce waste volumes and that produce final waste forms that are disposable, that is, that will be accepted by a final waste disposal site.

The fixed hearth plasma arc process provides a relatively near-term solution to these technology needs. Plasma arc technology has been in industrial use for many years for metal ore smelting, metal and refractory production and recycling, and metal cutting and welding. Plasma arc thermal treatment units are commercially available for treating non-radioactive industrial and municipal wastes. The Fixed

Hearth Plasma Arc mixed low-level waste treatment development project represents a relatively low-risk modification and application of a proven technology to DOE's unique low-level radiological and hazardous waste stream processing requirements.

## ACCOMPLISHMENTS

Proof-of-concept test burns have been performed for materials in drums characteristic of DOE's waste streams but without the radioactive components. Wastes were effectively destroyed in the process and produced a vitrified, high-integrity final waste form.

## COLLABORATION/TECHNOLOGY TRANSFER

The plasma arc process can accept a wide variety of waste types including paper, cloth, plastics, metals, glass, soil, and sludges. The ongoing projects are directed to demonstrate the application of the plasma arc process to representative surrogate waste streams. This project is a collaboration between INEL, ORNL, MSE, SAIC and ReTech. The Principal Investigators on these plasma arc projects will work with MWIP's Program Manager (HQ/USDOE) to ensure that a high level of awareness of the capabilities of this technology is maintained in the waste treatment community, both within and external to DOE.

**For further information, please  
contact:**

**Dr. Paul W. Hart**  
U.S. Department of Energy  
(301) 903-7456

**Jeff Ruffner**  
Project Manager  
MSE, Inc.  
(406) 494-7412



## 1.10 DEPARTMENT OF ENERGY/U.S. AIR FORCE MEMORANDUM OF UNDERSTANDING

The Department of Energy/U.S. Air Force Memorandum of Understanding (DOE/USAF MOU) Program was formed to jointly reduce waste generation in common areas and avoid duplication of research efforts. The Program promotes the development of pollution prevention technologies, such as material substitution and advanced manufacturing techniques, to reduce or eliminate the generation of hazardous waste. Joint agency development permits leveraging of Federal funds.

DOE/USAF MOU will cover all phases involved in industrial processes (see Figure

1.10). It will help expedite future selection and implementation of the best technologies and show immediate and long-term effectiveness for DOE and USAF sites. The Program will conduct performance comparisons of available technologies under field conditions based on effectiveness with respect to the technology itself, risk reduction, and general acceptability.

Several projects have contributed to the establishment of a formal program between DOE and the USAF. Since the early 1980s, the Air Force Civil Engineering Support Agency (AFCESA), formerly the Air Force

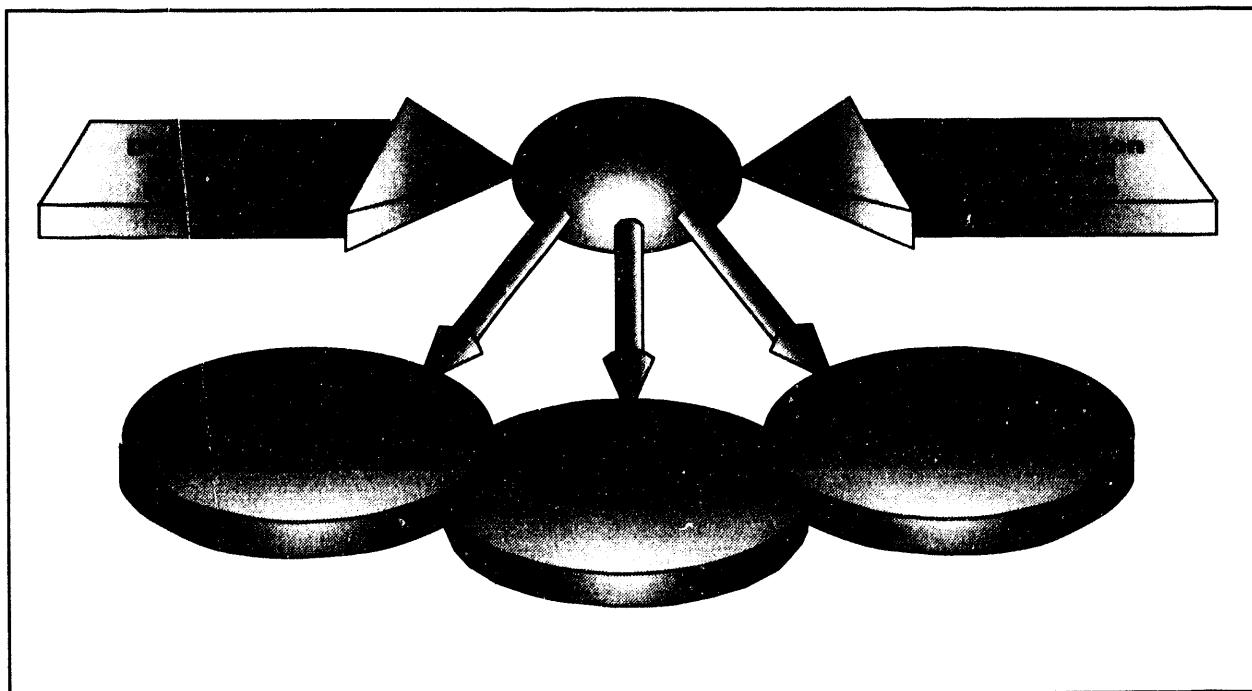


Figure 1.10. The industrial processes of the DOE/USAF MOU Program.

Engineering Services Center (AFESC), requested that INEL perform a variety of environmental projects. These included:

- Sodium Sulfide/Ferrous Sulfate Metals Precipitation;
- Metals Recovery from Sludge;
- Bicarbonate of Soda Stripping;
- Noncyanide Metal Strippers; and
- Biodegradable Solvent Substitution.

In 1988, a MOU was signed between EM and the Laboratory Commander of the AFESC. This MOU stated that the two organizations would jointly develop mutually beneficial environmental technologies, promote technology information exchange, and assist in arranging interlaboratory/industry partnerships.

FY92 was the first year for the formal program. The projects emphasize pollution prevention by addressing wastes regulated by RCRA, the Clean Air Act (CAA), and the Clean Water Act (CWA). The Spray Casting Project, conducted by MSE, Inc., is a major component activity of the DOE/USAF MOU. This project is described in greater detail in Section 1.11 of this publication.

**For further information, please contact:**

**Alison Johnson**  
Program Manager  
U.S. Department of Energy  
(301) 903-7923

## 1.11

# SPRAY CASTING PROJECT

### TASK DESCRIPTION

This task is developing a new manufacturing and repair process to replace electroplating by applying coatings directly onto substrates, and spraying the molten coating material through a specially designed nozzle. The process utilizes a controlled aspiration process to spray liquid metal into a mold for near-net shape forming applications or on a substrate as a protective coating (see Figure 1.11). This technology has a dual application for both DOE and the Air Force.

The DOE's Office of Technology Development is supporting waste minimization efforts in the fabrication of special nuclear materials. This portion of the project involves spray forming various DOE components to near-net shapes. Spray forming greatly reduces the amount of waste generated during the fabrication of these components compared to existing techniques. Despite a dramatic decrease in production requirements at DOE Defense Program facilities, manufacturing needs still exist. Work is continuing to complete installation and testing of the robotics arm, fabrication and evaluation of near-net shape components, and spraying and evaluation of coatings for corrosion protection.

The Air Force effort is directed at replacement of chromium electroplating as a repair/refurbishment technique on aviation

parts. Chromium plating processes are being replaced by a thermally sprayed coating of equal or superior mechanical and physical properties. The coating portion of this project is being demonstrated at Robbins Air Force Base (AFB) in Warner-Robbins, Georgia. The USAF portion of the project is sponsored by the USAF Civil Engineering Support Agency at Tyndall AFB. Design and fabrication continues of pilot equipment for installation at Robbins AFB, as does verification testing of selected Air Force parts.

### TECHNOLOGY NEEDS

The Spray Casting technology will avoid or eliminate waste as a result of material or process changes from existing methods, and will reduce the generation of waste material at the source. Downsizing, decontamination, and decommissioning are now becoming the

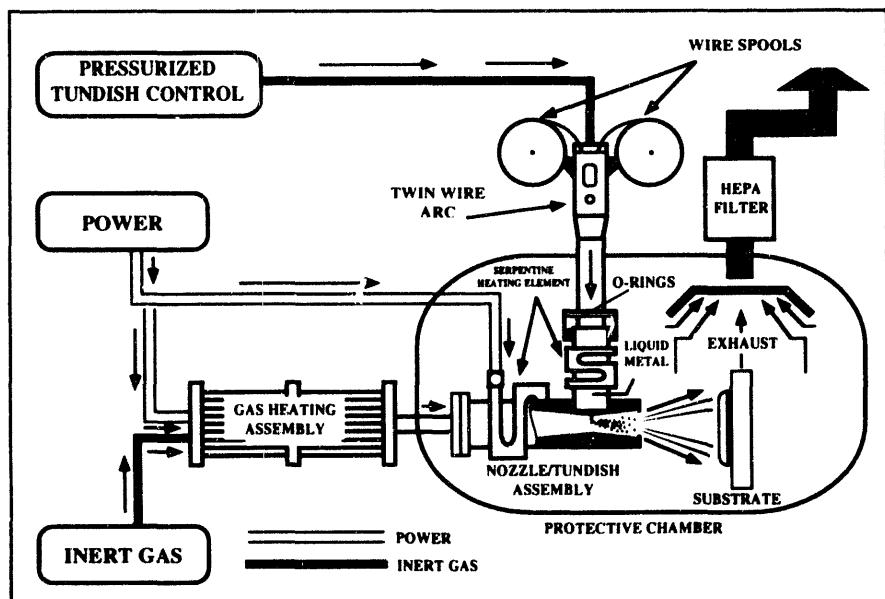


Figure 1.11. Controlled Aspiration Process.

focus at DOE facilities such as the ORNL Y-12 Plant. Therefore, spray casting, either as a coating or for producing near-net shape parts, would be of significant value to the DOE Complex. The Air Force has a basic need to replace chromium electroplating as a means of repair/refurbishment of aviation parts because hexavalent chromium, a by-product of the plating operation, is a well known carcinogen, and its safe disposal is difficult and expensive. Spray casting of thin, well-adhering, hard metallic coatings onto parts can provide a replacement process for the chromium electroplating. This requirement is directed by RCRA relative to disposal requirements for listed waste streams. Five Air Force Logistics and Service Centers generate approximately 1,000 gallons of hazardous chromium plating waste per week. Disposal costs are \$2-3 million per year.

arm for the fabrication of near-net shape components, and initiated spraying of coatings for corrosion protection.

- Completed hardware development.
- Completed process qualification testing.
- Conducted reactivity tests using aluminum to determine how oxygen contamination in the atmosphere surrounding the spray plume might affect the as-spray product.
- Conducted surrogate alloy spraying experiments using the same spray system and monitoring system component configurations as the reactivity tests using converging/diverging nozzles to spray the surrogate alloy.

## ACCOMPLISHMENTS

- Completed Wright Laboratory testing and qualification to Air Force standards.
- Identified Warner-Robbins Air Logistic Center as location for technology demonstration.
- Initiated design and fabrication of pilot equipment for installation at Warner-Robbins, and initiated verification testing of selected Air Force parts.
- Completed engineering evaluation of the sprayed deposit characteristics of reactive materials, completed specification and procurement of the robotics

## COLLABORATION/TECHNOLOGY TRANSFER

The spray casting process will be transferred to DOE Defense Program manufacturing facilities once the technology is demonstrated. The project is being developed in collaboration with MSE, Inc., DoD, and ORNL. Boeing and Wright-Patterson AFB have been involved in a test series conducted to provide an engineering evaluation of the spray process for the Air Force portion of the project. Tests including chemistry, metallurgy, internal stress measurement, hardness, corrosion resistance, abrasion resistance, and adhesion strength of the sprayed coating have been performed.

**For further information, please  
contact:**

**Alison Johnson**  
Program Manager  
U.S. Department of Energy  
(301) 903-7923



## **Other Federal Agency and DOE Collaborative Projects**

### **Section 2.0**



## 2.1 MINE WASTE TECHNOLOGY PILOT PROGRAM

### TASK DESCRIPTION

Mining waste generated by active and inactive mining production facilities and its impact on human health and the environment is a growing concern for government entities, private industry, and the general public. The mission of the Mine Waste Technology Pilot Program (MWTPP)(see Figures 2.1a, b, and c) is to advance the understanding, development, and application of engineering solutions to national environmental issues resulting from the past practices of mining, milling, leaching, and smelting of metallic ores. To accomplish this mission, the MWTPP has identified within the Program the following activities:

- identification and prioritization of mining waste issues;
- development of a quality assurance plan for the program as a whole;
- conduct large pilot- and field-scale demonstrations of promising technologies;
- conduct bench- and small-scale research on promising technologies;
- perform technology transfer of information gathered during the pilot program; and
- establish training and educational programs directed toward personnel in mine waste treatment.

### ACCOMPLISHMENTS

To date, the MWTPP has developed five documents under Activity 1 that relate to specific mine waste issues. The quality assurance plan for the Program as a whole has been completed and implemented under Activity 2. Five field-scale demonstrations under Activity 3 have been approved by the management committee(see Section 2.2). Field construction activities are nearing completion on three of these technologies with testing scheduled to begin after construction completion. Five bench-scale research projects have been developed and are currently operating under Activity 4. The final report on the first of these projects will be completed within the first portion of FY95. The projects under Activity 5 have consisted of a number of sponsored



Figure 2.1a. Headframe of mine shaft and waste piles at the Lilly/Orphan Boy Mine, site of the SRB Demonstration Project of the MWTPP.

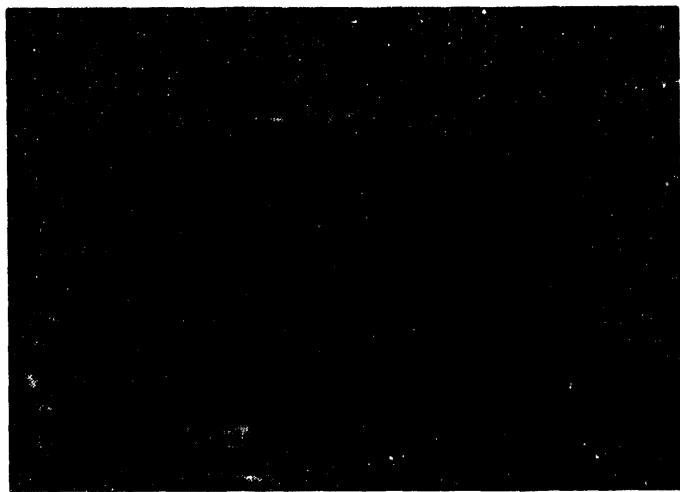


Figure 2.1b. The Mike Horse Mine adit, site of the Clay-Based Grouting Demonstration Project of the MWTTP.

seminars, workshops, symposiums, and annual report publications. Activity 6 has established a graduate emphasis program at Montana Tech that currently has more than 20 students enrolled. This activity has also sponsored a number of educational activities for grade school, middle school, and high school level students.

## TECHNOLOGY NEEDS

Mine wastes from inactive and abandoned mines are a major environmental liability for Federal, state, and local government entities, and private business. No viable technology is available to address many of the wasteforms generated by these mining sites. Numerous problems arise from the long-term, cradle-to-grave nature of these waste forms. Specific problems that have been identified deal with the control and mitigation of acid generation, the mobility of

toxic constituents generated by mining activities in both water and air, and the recovery of resources from wastes. A number of conventional technologies are in use at mining sites, but for the most part, the use of these technologies is viewed as interim, stop-gap measures until actual controls or solutions are developed.

## COLLABORATION/ TECHNOLOGY TRANSFER

The MWTTP is jointly administered by the EPA and DOE. The program also has an oversight committee that consists of individuals from the EPA, DOE, U.S. Bureau of Mines, the U.S. Forest Service, the U.S. Bureau of Land Management, the Western Governors' Association, the State of Idaho, the State of Montana, and the Northern Plains Resource Council. The program is in direct collaboration on projects within Activities 2 and 3 with the U.S. Bureau of Mines, Montana Tech, the Center for Biofilm Engineering, Noranda Mining Corporation, ASARCO, Inc., ARCO Inc., Montana Gold Properties Inc., FMC Corporation, TVX Mining Inc., the

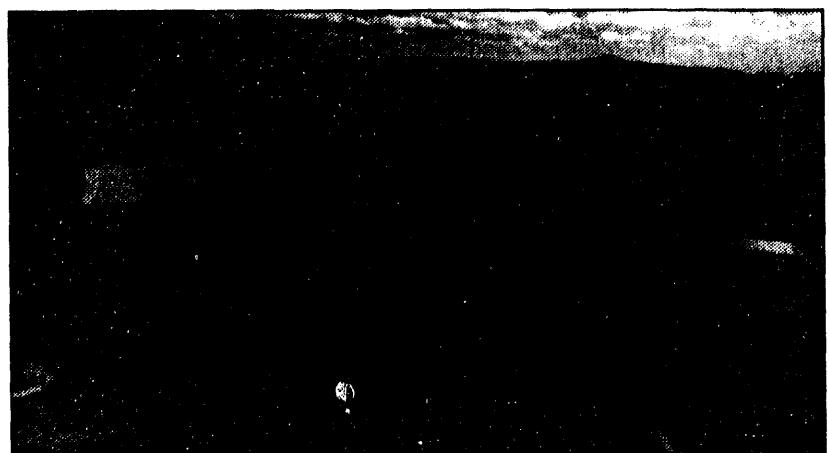


Figure 2.1c. The Crystal Mine Complex, site of the Remote Mine Complex, site of the Remote Mine Site Demonstration Project of the MWTTP.

ation Program. Activity 5 processes have involved direct collaboration with many of the previously mentioned organizations in addition to Placer Dome Mining Inc., and Pegasus Mining, Inc. Collaboration within Activity 6 has involved Montana Tech, Montana State University, University of New Mexico, Kansas State University, the University of Nevada at Reno, the University of Utah, as well as several local school districts.



**For further information, please contact:**

**Roger Wilmoth**  
Program Manager  
U.S. Environmental Protection Agency  
(513) 569-7509

**Creighton Barry**  
Project Manager  
MSE, Inc.  
(406) 494-7502



## **2.2 MINE WASTE TECHNOLOGY PILOT PROGRAM ACTIVITY III PROJECTS**

---

Acid mine drainage forms when normally clean water comes in contact with metal sulfide minerals in the presence of air. The valuable minerals that are exploited by mining activities are metal sulfides.

Personnel from EPA's Region 8 have identified several hundred mine sites where acid mine drainage emanates from point sources and drains directly into surface waters. The environmental damage caused by these acidic, metal-laden waters can be severe to aquatic organisms. Hundreds of miles of surface water courses are affected by these drainages in the western United States.

The first three demonstrations of Activity III of the MWTTP all relate to the prevention and/or control of acid mine drainage.

### **Project 1 - Remote Mine Site Demonstration Project**

The purpose of Activity III, Project 1, is to develop a water-treatment process facility at a remote mine site, which is capable of treating a flow of acidic, metal-laden water. The process facility should be self-regulating for variable flow rates and capable of operating without the addition of external power and without operator assistance for extended periods of time in harsh conditions (4-5 months). The site chosen for this project is the Crystal Mine, a remote, inactive, mine site located 7 miles north of the community of Basin, Montana, immediately adjacent to Uncle Sam Creek. Between 20 and 50 gallons per minute (gpm) of acidic, metal-laden water drains from

the lower portal of the mine workings directly into Uncle Sam Creek.

Bench-scale testing of the process chemistry was completed in FY94, all the legal and environmental permits needed to construct the field-scale unit have been acquired, the field-scale process train has been designed and reviewed, and finally, a water treatment facility consisting of six stages has been constructed at the Crystal Mine. The six stages of the facility are initial oxidation, alkaline reagent addition, final oxidation, initial solid-liquid separation, and neutralization (pH adjustment), and final solid-liquid separation. Operation and testing of this facility began on August 26, 1994.

### **Project 2 - Clay-Based Grouting Demonstration Project**

The purpose of Activity III, Project 2, is to produce a subsurface barrier formed of clay grout that will prevent clean water from coming in contact with sulfide minerals contained within the mineralized portion of an abandoned mine. This barrier will thus prevent the formation of acid mine drainage. The site chosen for this project is the Mike Horse Mine, a remote, inactive, mine site located 12 miles east of the community of Lincoln, Montana, immediately adjacent to Mike Horse Creek. Between 50 and 100 gpm of acidic, metal-laden water drains from the 300-foot-level portal of the mine workings directly into Mike Horse Creek, which is one of the creeks that forms the Blackfoot River.

All the legal and environmental permits needed to place the grout in the subsurface have been acquired. The geology, geochemistry, and hydrology of the mine site were characterized during FY93-94. Working agreements with the mine owners and the Ukrainian corporation that developed the clay grouting formulation to be used in the demonstration have been acquired, and the field-scale application of this technology will take place early in FY95. Testing of this application will begin immediately after emplacement.

### **Project 3 - Sulfate-Reducing Bacteria Demonstration Project**

The purpose of Activity III, Project 3, is to demonstrate the use of sulfate-reducing bacteria (SRB) for the treatment of acid mine drainage. The bacteria will be used in an innovative application by placing an organic substrate containing the bacteria within the subsurface mine workings of the chosen site; these bacteria have been shown to metabolically produce hydrogen sulfide and alkalinity from sulfate that is dissolved in water. Acid mine drainage contains sizeable quantities of dissolved sulfate in addition to acid and metals. The hydrogen sulfide produced by the SRBs will react with the metals in the acid mine drainage to produce solid metal sulfides that will precipitate out of solution. The alkalinity, which is also produced by the bacterial action, will serve to neutralize the acidic component of the drainage. The site chosen for this project is the Lilly/Orphan Boy Mine, a remote, inactive, mine site located 10 miles south of the community of Elliston, Montana, immediately adjacent to Telegraph Creek. Between 3 and 5 gpm of acidic, metal-laden water drains from a collapsed portal of the mine workings directly into Telegraph Creek.

All the legal and environmental permits needed to conduct the demonstration and a

working agreement with the mine owner has been acquired. The organic substrate was placed into the mine workings on August 29 and 30, 1994. Testing of this technology application began immediately after this placement.

### **Project 4 - Nitrate Removal Demonstration Project**

The purpose of Activity III, Project 4, is to demonstrate a number of technologies to remove nitrate from mine water. Nitrate is found in mine water as a result of a number of mining processes, including blasting with nitrate-based blasting agents, destruction of cyanide used in leaching precious metals from rocks, and fertilization during reclamation of ground disturbed by mining activities.

Excess nitrate in water is considered to be an environmental pollutant due to the propensity of nitrate to increase the biological activity in water. Such increases in biological activity can cause algal blooms, an increase in biological oxygen demand, and eutrophication. The technologies that will be tested are ion-exchange, electrochemical ion-exchange, and biological denitrification. The site chosen for this project is the Mineral Hill Mine, an operating mine located near the community of Gardner, Montana. Approximately 10 gpm of nitrate-enriched water is discharged from the 600-foot-level portal of the mine into the tailings pond of the operation.

Funding for this project has been approved by EPA but has not yet been received.

### **Project 5 - Biocyanide Demonstration Project**

The purpose of Activity III, Project 5, is to demonstrate the use of bacteria to destroy the cyanide found in mine wastes that result from

using this chemical for leaching precious metals from ores. Residual cyanide in these wastes is a strong hazard to the environment; cyanide is a specific poison to many life forms, including humans. Cyanide also has the ability to complex with many substances, specifically metals, and strongly increase the solubility and therefore the mobility of those substances.

This project will test two biological methods of destroying cyanide in mine wastes. The first of these technologies is a bacteria known as Pseudomonas putida. This bacteria has been isolated by researchers from the Center for Biofilm Engineering at Montana State University and Selma University in Alabama. The second technology that will be tested is the use of indigenous bacteria that also show the ability to destroy cyanide. These two technologies will be tested against each other side-by-side to determine which process is best used to destroy residual cyanide in a spent heap from a heap leaching mine operation.

The site chosen for this project is the Paradise Peak Mine owned by FMC Corporation near Gabbs, Nevada. This is an operating, precious-metal, heap-leach mine.

Funding for this project has been approved by EPA but has not yet been received.

**For further information, please contact:**

**Roger Wilmoth**  
Program Manager  
U.S. Environmental Protection Agency  
(513) 569-7509

**Creighton Barry**  
Project Manager  
MSE, Inc.  
(406) 494-7502

## 2.3

## **U.S. ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORY PROJECTS**

### **CONSTRUCTION ENGINEERING RESEARCH LABORATORY (CERL) PLASMA/PYROTECHNIC ORDNANCE PLASMA DEMONSTRATION**

DOE is assisting the U.S. Army with its need to dispose of hazardous waste within the DoD Complex with safe, environmentally acceptable methods. WETO testing determined the feasibility of using plasma arc technology to treat hazardous waste and to minimize or eliminate resulting hazardous wasteforms. The focus of the current program is to develop a production system design, screen additional waste forms, and perform the continued testing necessary to meet these objections.

The U.S. Army and the Army Corp of Engineers currently have numerous fuse devices and other ordnances stockpiled for disposal. This task involves the development of the Plasma Arc Centrifugal Treatment process and associated equipment to support full-scale implementation of the technology for the treatment of this waste. Specific development tasks include development of systems for the handling and feeding of various waste forms, modifications to system off-gas configuration to ensure proper destruction of organic compounds, and studies of slag conditioning to enhance system operability and minimize waste volume.

Design and fabrication of equipment and process upgrades have been completed for the off-gas and afterburner systems. These upgrades are intended to increase system oper-

ability by ensuring sufficient residence time for proper destruction of organic compounds. Testing of these upgrades will be conducted following installation. Upgrades to the torch and power supply are being designed to enhance system operability and scale up power capability to more closely simulate full-scale equipment. Ongoing testing and slag studies have demonstrated the ability to process very high metal content feeds and provided information that will allow the final waste volume to be minimized. All of these efforts focused toward the ultimate goal of a conceptual design for a full-scale system.

This technology was originally developed by ReTech, Inc., and initially demonstrated by DOE. Under an agreement with DOE, the U.S. Army is currently using the equipment installed at WETO to develop the plasma arc process for application to DoD hazardous waste. While the two agencies are not directly collaborating, the programs are being conducted to share and leverage data. There are currently no industrial partners involved in this task.

### **CERL HEAVY METALS REMEDIATION**

MSE, Inc., will perform a series of waste minimization and environmental restoration projects at the Watervliet Arsenal (WVA) in Watervliet, New York. A component of the U.S. Army Materiel Command, the Watervliet Arsenal consists of 1.2 million sq. feet of manufacturing floor space. It produces can-

nons and other products serving DoD and allied countries.

The Watervliet Projects, funded by the DoD through the Environmental Engineering Division, U.S. Army Construction Engineering Research Laboratories (CERL), are designed to demonstrate and evaluate non-plasma technologies and their effectiveness to treat DoD and DOE chosen waste forms. The overall intent of this program will be to leverage both DoD and DOE resources in an effort to develop and demonstrate viable treatment technologies to solve some specific environmental problems. WETO and CERL staff will work together by combining resources in an attempt to find viable treatment alternatives for various waste streams. The projects will expand the environmental management scope of WETO.

The following projects have been prioritized by the WVA and CERL:

- Manufacturing Operation Oil Waste
- Chromium Waste Streams/Sulfate Reducing Bacteria
- Vessel Plating Facility Closed Loop Plating
- Spent Acid Purification
- Water Treatment Automation
- Heavy Metal Soils Remediation

**For further information, please contact:**

**Plasma/Pyrotechnic**

**Jeff Ruffner**

Thermal Program Manager

MSE, Inc.

(406) 494-7412

**CERL Heavy Metals Remediation**

**Mike G. Lewis**

Project Manager

MSE, Inc.

(406) 494-7443

## TASK DESCRIPTION

The U.S. Army and the Army Corps of Engineers currently have numerous fuze devices and other ordnance stockpiled for disposal. This task involves the development of the Plasma Arc Centrifugal Treatment process and associated equipment to support full-scale implementation of the technology for the disposal of fuze and ordnance devices. Specific development tasks include development of systems for the handling and feeding of ordnance, modifications to system off-gas configuration to minimize plugging and ensure proper destruction of organic compounds, and studies of slag conditioning to enhance system operability and minimize waste volume. The final deliverable for this effort will be the conceptual design and engineering specification for a plasma arc system for ordnance destruction.

## ACCOMPLISHMENTS

Design and fabrication of equipment and process upgrades have been completed for the off-gas and afterburner systems. These upgrades are intended to increase system operability by minimizing the potential to plug the off-gas system and ensure sufficient residence time for proper destruction of organic compounds. Testing of these upgrades will be conducted following installation. Upgrades to the torch and power supply are being designed to enhance system operability and scale up power capability to more closely simulate full-scale equipment. Ongoing testing and slag studies have demonstrated the ability to pro-

cess very high metal content feeds and provided information that will allow the final waste volume to be minimized.

## TECHNOLOGY NEEDS

Increasing environmental restrictions are making open burning/open detonation of ordnance an unacceptable method of disposal. Previous screening tests have shown that plasma technology has the ability to process representative ordnance and fuze devices into an environmentally benign waste form.

Attempts to process ordnance in conventional incinerators have been unsuccessful for representative ordnance types. Munitions containing smokes and dyes can overload pollution abatement equipment, while flare and illumination devices can produce high localized temperatures that damage incinerator combustion chambers. In addition, a number of devices contain electronic components or general configurations that remain classified. Conventional incinerators may not guarantee physical destruction satisfactorily to address these issues. Application of the Plasma Arc Centrifugal Treatment system to the disposal of stockpiled ordnance and fuze devices has the potential to satisfy environmental and security issues.

## COLLABORATION/TECHNOLOGY TRANSFER

This technology was originally developed by ReTech, Inc., and initially demonstrated by

DOE. Under an agreement with DOE, the U.S. Army is currently using the equipment installed at WETO to develop the process for application to pyrotechnic ordnance while the Army Corps of Engineers is developing it for application to fuze and ordnance devices. While the two agencies are not directly collaborating, the programs are being conducted to share and leverage data. There are currently no industrial partners involved in this task.

**For further information, please contact:**

**Hany Zaghloul**  
Program Manager  
U.S. Army Corps of Engineers  
(217) 373-3486

**Jeff Ruffner**  
Project Manager  
MSE, Inc.  
(406) 494-7412

## 2.5

# SODIUM SULFIDE/FERROUS SULFATE METALS PRECIPITATION PROCESS

## TASK DESCRIPTION

This task involves the further development of an Air Force patented technology for the removal of heavy metals from water streams. The Sodium Sulfate Ferrous Sulfate process is a chemical precipitation process which reduces sludge volumes and removes contaminants from industrial waste water treatment plants. The process can be applied to waste streams containing chrome, cadmium, copper, lead, nickel, and zinc. The process has been incorporated into the industrial waste water treatment plan at Tinker Air Force Base, in Oklahoma. The purpose of this task was to skid mount the technology for application on smaller waste streams at Air Force Air Logistic Centers.

## ACCOMPLISHMENTS

Based on the experience at the Tinker AFB industrial waste water treatment plant, analytical work done at Columbus AFB, Mississippi, and a survey of other Air Force Logistics Centers, a 2-to-10 gallon/minute skid-mounted unit was designed at WETO. The unit is currently undergoing testing by the Air Force Armstrong Laboratory, at Columbus AFB.

## COLLABORATION/TECHNOLOGY TRANSFER

The design of the skid-mounted unit was done by MSE, Inc., and Environmental Research and Development Inc., of Idaho Falls, ID.

## TECHNOLOGY NEEDS

In 1980, EPA regulations classified metal-bearing sludges generated at the U.S.D. Air Force Air Logistics Centers as hazardous waste. Due to these regulations, the sludges require costly handling and disposal in hazardous waste landfills. The waste streams at the Air Logistics Centers come from operations such as chrome plating for parts repair, plane exterior refurbishing, parts manufacture, and photo laboratories. These products are carried into rinse water which is treated at waste water treatment plants. Most Air Logistic Centers have municipal waste water treatment plants which are not equipped to handle hazardous waste, and alternative to disposal needs to be found.

**For further information, please contact:**

**Captain Bill Gooden**  
U.S. Army  
Tyndall AFB  
(904) 283-6239

**Mary Ann Harrington-Baker**  
Project Manager  
MSE, Inc.  
(406) 494-7240



**FY94 Activities Funded  
Through The Western  
Environmental Technology  
Office, Butte, Montana**

**Section 3.0**



### **3.0 OFFICE OF TECHNOLOGY DEVELOPMENT EM-50 FY94 ACTIVITIES AT THE WESTERN ENVIRONMENTAL TECHNOLOGY OFFICE, BUTTE, MONTANA (By Program Element)**

| <b>TTP<br/>NUMBER</b>  | <b>TITLE</b>   |
|--|--|
| <b>HEAVY METALS CONTAMINATED SOILS PROJECT</b><br>PE031001       | <b>SOIL WASHING</b>  |
| <b>IN-SITU REMEDIATION TECHNOLOGY DEVELOPMENT IP</b><br>PE031002 | <b>BEFITO PROCESS/MACROPHYTE REMEDIATION OF CONTAMINATED SOILS</b> |
| <b>RESOURCE RECOVERY PROGRAM</b><br>PE021104                     | <b>RESOURCE RECOVERY PROJECT</b>                                   |
| PE341004   | CLEAN OPTION STRATEGY FOR BERKELEY PIT REMEDIATION                 |
| <b>MINIMUM ADDITIVE WASTE STABILIZATION</b><br>PE021105          | <b>MINIMUM ADDITIVE WASTE STABILIZATION</b>                        |
| <b>PROGRAM SUPPORT</b><br>PE025001                               | <b>TPM SUPPORT</b>   |
| <b>DOE/AIR FORCE MOA</b><br>PE021301                             | <b>SPRAY CAST TO NEAR NET SHAPE/QUALITY WEAR RESISTANT COATING</b> |
| <b>HAZARDOUS &amp; MIXED WASTE DESTRUCTION IP</b><br>PE021202    | <b>FIXED HEARTH PLASMA ARC FOR MIXED WASTE TREATMENT (RETECH)</b>  |



**How to Get Involved  
With The DOE  
Office of Environmental  
Management**

**Section 4.0**



## 4.0

# HOW TO GET INVOLVED WITH THE DEPARTMENT OF ENERGY OFFICE OF ENVIRONMENTAL MANAGEMENT

DOE provides a range of programs and services to assist universities, industry, and other private-sector organizations and individuals interested in developing or applying environmental technologies. Working with DOE Operations Offices and M&O contractors, EM uses conventional and innovative mechanisms to identify, integrate, develop, and adapt promising emerging technologies. These mechanisms include contracting and collaborative arrangements, procurement provisions, licensing of technology, consulting arrangements, reimbursable work for industry, and special consideration for small business.

### **Cooperative Research and Development Agreements**

EM will facilitate the development of subcontracts, R&D contracts, and cooperative agreements to work collaboratively with the private sector.

EM uses Cooperative Research and Development Agreements (CRADAs) as an incentive for collaborative R&D. CRADAs are agreements between a DOE R&D laboratory and any non-Federal source to conduct cooperative R&D that is consistent with the laboratory's mission. The partner may provide funds, facilities, people, or other resources. DOE provides the CRADA partner access to facilities and expertise; however, no Federal funds are provided to external participants. Rights to inventions and other intellectual property are negotiated between the laboratory and participant, and certain data that are generated may be protected for up to 5 years.

Consortia will also be considered for situations where several companies will be combining their resources to address a common technical problem. Leveraging of funds to implement a consortium can offer a synergism to overall program effectiveness.

### **Procurement Mechanisms**

DOE EM has developed an environmental management technology development acquisition policy and strategy that uses phased procurements to span the RDDT&E continuum from applied R&D concept feasibility through full-scale remediation. DOE EM phased procurements make provisions for unsolicited proposals, but formal solicitations are the preferred responses. The principle contractual mechanisms used by EM for industrial and academic response include ROA and PRDA. EM uses the Research Opportunity Announcements (ROA) to solicit advanced research and technologies for a broad range of cleanup needs. The ROA supports applied research ranging from concept feasibility through full-scale demonstration. In addition, the ROA is open continuously for a full year following the date of issue and includes a partial procurement set aside for small businesses. Typically, ROAs are published annually in the *Federal Register* and the *Commerce Business Daily*, and multiple awards are made.

**Program Research and Development Announcements (PRDAs)** are program announcements used to solicit a broad mix of R&D and DT&E proposals. Typically, a PRDA is used to solicit proposals for a wide-range of technical solutions to specific EM problem areas. PRDAs may be used to solicit proposals for contracts, grants, or cooperative agreements. Multiple awards, which may have dissimilar approaches or concepts, are generally made. Numerous PRDAs may be issued each year.

In addition to PRDAs and ROAs, EM uses financial assistance awards when the technology is developed for public purpose. Financial assistance awards are solicited through publication in the *Federal Register*. These announcements are called Program Rules. A Program Rule can either be a one-time solicitation or an open-ended, general solicitation with annual or more frequent announcements concerning specific funding availability and desired R&D agreements. The Program Rule can also be used to award both grants and cooperative agreements.

EM awards grants and cooperative agreements if fifty-one percent or more of the overall value of the effort is related to a public interest goal. Such goals include possible non-DOE or other Federal agency participation and use, advancement of present and future U.S. capabilities in domestic and international environmental cleanup markets, technology transfer, advancement of scientific knowledge, and education and training of individuals and business entities to advance U.S. remediation capabilities.

### **Licensing of Technology**

DOE contractor-operated laboratories can license DOE/EM-developed technology and software to which they elect to take title. In other situations where DOE owns title to the resultant inventions, DOE's Office of General Counsel will do the licensing. Licensing activities are done within existing DOE intellectual property provisions.

### **Technical Personnel Exchange Assignments**

Personnel exchanges provide opportunities for industrial and laboratory scientists to work together at various sites on environmental restoration and waste management technical problems of mutual interest. Industry is expected to contribute substantial cost-sharing for these personnel exchanges. To encourage such collaboration, the rights to any resulting patents go to the private sector company. These exchanges, which can last from 3 to 6 months, are opportunities for the laboratories and industry to better understand the differing operating cultures, and are an ideal mechanism for transferring technical skills and knowledge.

### **Consulting Arrangements**

Laboratory scientists and engineers are available to consult in their areas of technical expertise. Most contractors operating laboratories have consulting provisions. Laboratory employees who wish to consult can sign non-disclosure agreements, and are encouraged to do so.

## **Reimbursable Work for Industry**

DOE laboratories are available to perform work for industry, or other Federal agencies, as long as the work pertains to the mission of a respective laboratory and does not compete with the private sector.

The special technical capabilities and unique facilities at DOE laboratories are an incentive for the private sector to use DOE's facilities and contractors expertise in this reimbursable work for industry mode. An advanced class patent waiver gives ownership of any inventions resulting from the research to the participating private sector company.

## **EM Small Business Technology Integration Program**

The EM Small Business Technology Integration Program (SB-TIP) seeks the participation of small businesses in the EM Research, Development, Demonstration, Testing and Evaluation programs. Through workshops and frequent communication, the EM SB-TIP provides information on opportunities for funding and collaborative efforts relative to advancing technologies for DOE environmental restoration and waste management applications.

EM SB-TIP has established a special EM procurement set aside for small firms (500 employees or less) to be used for applied research projects, through its ROA. The program also serves as the EM liaison to the DOE Small Business Innovation Research (SBIR) Program Office, and interfaces with other DOE small business offices, as well.

## **CONTACT**

**David W. Geiser, Acting Director**  
International Technology Exchange Division  
Environmental Restoration and Waste  
Management Technology Development  
U.S. Department of Energy  
Washington, D.C. 20585  
(301) 903-7940

## **EM Central Point of Contact**

The EM Central Point of Contact is designed to provide ready access to prospective research and business opportunities in waste management, environmental restoration, and decontamination and decommissioning activities, as well as information on EM-50 IPs and IDs. The EM Central Point of Contact can identify links between industry technologies and program needs, and

provides potential partners with a connection to an extensive complex-wide network of DOE Headquarters and field program contacts.

The EM Central Point of Contact is the best single source of information for private-sector technology developers looking to collaborate with EM scientists and engineers. It provides a real-time information referral service to expedite and monitor private-sector interaction with EM.

To reach the EM Central Point of Contact, call 1-800-845-2096 during normal business hours (Eastern time).

### **Office of Research and Technology Applications**

Office of Research and Technology Applications (ORTAs) serve as technology transfer agents at the Federal laboratories, and provide an internal coordination in the laboratory for technology transfer and an external point of contact for industry and universities. To fulfill this dual purpose, ORTAs license patents and coordinate technology transfer activities for the laboratory's scientific departments. They also facilitate one-on-one interactions between the laboratory's scientific personnel and technology recipients, and provide information on laboratory technologies with potential applications in private industry for state and local governments.

**For more information about these programs and services, please contact:**

**Claire Sink, Director**  
Technology Integration Division  
Environmental Restoration and Waste  
Management Technology Development  
U.S. Department of Energy  
Washington, D.C. 20585  
(301) 903-7928

## **Acronyms**

## **Section 5.0**



## 5.0

## ACRONYMS

|        |   |
|--------|---|
| AFB    | Air Force Base                                      |
| AFCESA | Air Force Civil Engineering Support Agency          |
| AFESC  | Air Force Engineering Services Center               |
| ANL    | Argonne National Laboratory                         |
| ASH    | Air-sparged Hydroclone                              |
| ASME   | American Society of Mechanical Engineers            |
| AUB    | American-Ukraine Biotech                            |
| BWID   | Buried Waste Integrated Demonstration               |
| CAA    | Clean Air Act                                       |
| CCJ    | Campbell Centrifugal Jig                            |
| CWA    | Clean Water Act                                     |
| CDIF   | Component Development and Integration Facility      |
| CRADA  | Cooperative Research and Development Agreements     |
| DoD    | U.S. Department of Defense                          |
| DOE    | U.S. Department of Energy                           |
| EM     | DOE Office of Environmental Management              |
| EPA    | U.S. Environmental Protection Agency                |
| ESPIP  | Efficient Separations Processing Integrated Program |
| FE     | DOE Office of Fossil Energy                         |
| FEMP   | Fernald Environmental Management Project            |
| FST    | Fractionation Separation Technology                 |
| HGMS   | High-gradient Magnetic Separation                   |
| INEL   | Idaho National Engineering Laboratory               |
| IP     | Integrated Program                                  |
| ID     | Integrated Demonstration                            |
| IIA    | Innovation Investment Area                          |
| ISR-IP | In Situ Remediation Integrated Program              |
| LANL   | Los Alamos National Laboratory                      |
| LDFs   | Land Disposal Facilities                            |
| MAWS   | Minimum Additive Waste Stabilization Program        |
| MHD    | Magnetohydrodynamic                                 |
| M&O    | Management and Operating (contractors)              |
| MOU    | Memorandum of Understanding                         |
| MSE    | Mountain States Energy, Inc.                        |
| MWIP   | Mixed Waste Integrated Program                      |
| MWTPP  | Mine Waste Technology Pilot Program                 |
| NTS    | Nevada Test Site                                    |
| ORNL   | Oak Ridge National Laboratory                       |
| ORTA   | Office of Research and Technology Applications      |
| OTD    | DOE Office of Technology Development                |

|             |   |
|-------------|---|
| PETC        | Pittsburgh Energy Technology Center                               |
| PCF         | Plasma Centrifugal Furnace  |
| PCT         | Product Consistency Test  |
| PHP         | Plasma Hearth Process   |
| PNL         | Pacific Northwest Laboratory                                      |
| PRDA        | Program Research and Development Announcement                     |
| RCRA        | Resource Conservation and Recovery Act                            |
| R&D         | Research and Development  |
| RDDT&E      | Research, Development, Demonstration, Testing, and Evaluation     |
| ROA         | Research Opportunity Announcement                                 |
| RRP         | Resource Recovery Project   |
| RTDP        | Robotics Technology Development Program                           |
| SBIR        | Small Business Innovation Research Program Office                 |
| SB-TIP      | Small Business Technology Integration Program                     |
| SNL         | Sandia National Laboratory  |
| STIRS       | Science and Technology Information Retrieval System               |
| TCLP        | Toxicity Characteristic Leaching Procedure                        |
| TRU         | Transuranic waste   |
| TTR         | Tonopah Test Range  |
| UNR         | University of Nevada at Reno                                      |
| USAF        | U.S. Air Force  |
| USBOM       | U.S. Bureau of Mines  |
| USNA        | U.S. Naval Academy  |
| USTs        | Underground Storage Tanks   |
| VOC-Arid ID | Volatile Organic Compounds in Arid Soils Integrated Demonstration |
| WETO        | Western Environmental Technology Office                           |
| WGA         | Western Governors' Association                                    |

10/5/94

DATE  
FILE MED

