1 of 4

**Idaho National Engineering Laboratory
Waste Area Groups 1-7 and 10
Technology Logic Diagram
(Volume III)**

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MASTER

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Idaho National Engineering Laboratory

FOREWORD

The Idaho National Engineering Laboratory (INEL) Technology Logic Diagram (TLD) was developed to provide a decision support tool that relates Environmental Restoration (ER) and Waste Management (WM) problems at the INEL to potential technologies that can remediate these problems. The TLD uses information from the INEL Restoration Roadmap Document, the INEL Waste Management Operations Roadmap Document, the (Draft) Oak Ridge National Laboratory Technology Logic Diagram, the Oak Ridge K-25 Site Technology Logic Diagram, and the Hanford Site Wiring Diagram.

The TLD identifies the research, development, demonstration, testing, and evaluation needed to develop these technologies to a state that allows technology transfer and application to an environmental restoration need. It is essential that follow-on engineering and system studies be conducted to build on the output of this project. These studies will begin by selecting the most promising technologies identified in this TLD and finding an optimum mix of technologies that will provide a socially acceptable balance between cost and risk to meet the site windows of opportunity.

The TLD consists of three separate volumes:

- Volume I includes the purpose and scope of the TLD, a brief history of the INEL Waste Area Groups, and environmental problems they represent. A description of the TLD, definitions of terms, a description of the technology evaluation process, and a summary of each subelement, is presented. In addition to these sections, Appendix A contains descriptions and photographs of INEL contaminated sites.
- Volume II describes the overall layout and development of the TLD in logic diagram format. This section addresses the environmental restoration of contaminated INEL sites. Specific INEL problem areas/contaminants are identified along with technology solutions, the status of the technologies, precise science and technology needs, and implementation requirements.
- Volume III (this volume) provides the Technology Evaluation Data Sheets (TEDS) for Environmental Restoration and Waste Management (EM) activities that are referenced by a TEDS code number in Volume II. Each of these sheets represents a single logic trace across the TLD. These sheets contain more detail than provided for technologies in Volume II. Data sheets are arranged alphanumerically by the TEDS code number in the upper right corner of each sheet.

Volume III can be used in two ways: (1) technologies that are identified from Volume II can be referenced directly by using the TEDS codes, and (2) technologies and general technology areas (alternatives) can be located in the index in the back of this volume.

The technology evaluations contained in these volumes are based on the best available information during the compilation of the TLD. New or more accurate information is solicited to improve the TLD data base. Please send comments to J. S. Ferguson or R. H. Meserve, INEL

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1. CHARACTERIZATION

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TAN V-1, TAN V-2, TAN V-3, TSF-PM2A; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-31, CPP-79; OU 3-08, CPP-27.

Radioactive sumps, ponds, pits, trenches, etc.

OU 1-06, TSF-07; OU 3-08, CPP-15; OU 3-09, CPP-09, PBF-10; OU 7-13, RWMC-04.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-11, CPP-45.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-36;

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible, corrosive, metals; Radioactive, mixed radioactive, hazardous-organics, transuranic, Rocky Flats fire waste, Pu, and fuel end boxes.

Waste Form/Contaminants:

Debris-concrete, metals, paper, rags, sweepings, vehicles, diatomaceous earth, wood, glass; Soil; Concrete; Sludge; Floor; Asphalt/¹³⁷Cs, ¹³⁴Cs, ¹⁴⁴Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ¹⁵⁴Eu, ¹¹⁰Ag, ¹⁰⁶Ru, low levels of Pu, mercuric nitrate, nitric acid, Hg, Plutonium at low levels, kerosene, tri-butyle phosphates, ¹³⁷Cs and ¹³⁴Cs at 2R/hr., chromium, TCE, toluene, carbon tetrachloride, ¹³⁷Cs and ¹³⁴Cs at 200mR/hr.

SUBELEMENTS: Characterization

ALTERNATIVES: Laboratory characterization and analysis

TECHNOLOGY: Electron Spectroscopy for Chemical Analysis (ESCA)

A surface technique that operates on photo-electric effect. Electrons are ejected from the core of the atom with kinetic energies specific to the element.

STATUS: Accepted

Support/Application Evaluation:

- Mechanical Host Disturbance
- Thermal Host Disturbance
- Liquid Host Disturbance
- High-Energy Host Disturbance
- Gas-Phase Host Disturbance

Temporal Areas of Evaluation: Pretreatment
 During Treatment
 Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Risk Assessment
 Technical Assessment

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO₄,
 Hg, Pb,...)

SCIENCE AND TECHNOLOGY NEEDS:

Model studies are needed to identify binding energies for standard compounds of Tc and U for suspected matrices.

IMPLEMENTATION NEEDS:

Instrumentation and personnel currently exist at INEL.

COMMENTS:

Amount of Waste Produced--None, approximately a 5-mg sample is required.

Overall Cost--High capital costs, approximately \$200-\$600 per sample.

Efficacy/Strengths--Elemental and chemical state information from the outermost surface material (<10 nm) provide contaminant attachment and bonding mechanism information.

This is a mature technology.

EVALUATOR: D.P. Hoffmann Phone (615) 574-3896.

REFERENCES:

F. J. Gruthaner, *MRS Bulletin*, 12(6), 60-63 (1987).

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TAN V-1, TAN V-2, TAN V-3; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-31, CPP-79; OU 3-08, CPP-27.

Radioactive sumps, ponds, pits, trenches, etc.

OU 1-06, TSF-07; OU 3-08, CPP-15; OU 3-09, CPP-09; OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-36.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible, corrosive, metals; Radioactive, mixed radioactive, hazardous-organics, transuranic, Rocky Flats fire waste, Pu, and fuel end boxes.

Waste Form/Contaminants:

Debris-concrete, metals, paper, rags, sweepings, vehicles, diatomaceous earth, wood, glass; Soil; Concrete; Sludge; Floor; Asphalt/¹³⁷Cs, ¹³⁴Cs, ¹⁴⁴Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ¹⁵⁴Eu, ¹¹⁰Ag, ¹⁰⁶Ru, low levels of Pu, mercuric nitrate, nitric acid, Hg, Plutonium at low levels, kerosene, tri-butyle phosphates, ¹³⁷Cs and ¹³⁴Cs at 2R/hr., chromium, TCE, toluene, carbon tetrachloride, ¹³⁷Cs, and ¹³⁴Cs at 200mR/hr.

SUBELEMENTS: Characterization**ALTERNATIVES: Laboratory characterization and analysis****TECHNOLOGY: Auger Electron Spectroscopy (AES)**

A technique of speciation of analyte atoms by detection of characteristic gamma radiation caused by intershell electron transitions induced by X-ray excitation.

STATUS: Accepted

Support/Application Evaluation:	Mechanical Host Disturbance
	Thermal Host Disturbance
	Liquid Host Disturbance
	High-Energy Host Disturbance
	Gas-Phase Host Disturbance

Temporal Areas of Evaluation:	Pretreatment
	During Treatment
	Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO₄,
Hg, Pb,...)

SCIENCE AND TECHNOLOGY NEEDS:

Mature, model studies are needed to probe the host/contaminant effects for accurate depth profiling.

IMPLEMENTATION NEEDS:

Instrumentation and personnel exist within the three plants.

COMMENTS:

Amount of Waste Produced--Approximately 5 mg of sample is required. Sample preparation varies from none to extensive.

Overall Cost--High capital costs. High costs per sample, approximately 3-8 h/sample.

Efficacy/Strengths--Elemental, spatial, and depth profiling information is obtained from the surface region (<10 nm) of the sample. It is applicable to monitoring contaminant interaction with the host matrix and identifying complexation, location, and binding sites of the contamination. This is a mature technology.

EVALUATOR: D.P. Hoffmann Phone (615) 574-3896

REFERENCES: C.C. Chang, *MRS Bulletin*, 12(6), 70-74 (1987).

INEL PROBLEM SITES:

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 7-13, RWMC-04.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 4-06, CFA-44; OU 7-08, RI/FS.

Landfills.

OU 4-12, CFA-02, CFA-03.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Radioactive, mixed radioactive, hazardous-organics, transuranic, Rocky Flats fire waste, Pu, and fuel end boxes; Hazardous-metals, organics; Municipal-sanitary.

Waste Form/Contaminants:

Debris-paper, rags, sweepings, vehicles, diatomaceous earth, wood, metal, glass; Soil; Sludge; Solid; Liquid/⁶⁰Co, TCE, toluene, carbon tetrachloride, Pu, lead, paint thinner, chloroform, chromium, mercury, beryllium, trichloroethane.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ characterization and monitoring

TECHNOLOGY: Organic vapor monitoring

STATUS: Accepted

Support/Application Evaluation:	Mechanical Host Disturbance
	Thermal Host Disturbance
	Liquid Host Disturbance
	High-Energy Host Disturbance
	Gas-Phase Host Disturbance

Temporal Areas of Evaluation:	Pretreatment
	During Treatment

Deployment Evaluation:	Manual Applications
	Automated Applications
	Robotic Applications

Driver Evaluation:	Regulatory
	Risk Assessment
	Technical Assessment

Applicable Contaminant Evaluation: Organic (Oil, PCBs, VOCs,
TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:

This is a mature technology. We must ensure that radiation and the complex mixtures that may be present do not hamper the detection efficiency.

IMPLEMENTATION NEEDS:

We must adapt this maturing technology to allow detection of specific gases of interest that may not be currently available, and we must adapt our collection capabilities to allow for large area and limited access sampling.

Normal implementation needs. Instrument costs, \$3 - \$6K each.

COMMENTS:

Amount of Waste Produced--None

Overall Cost--Low capital costs; very low cost per analysis (approximately \$1).

Efficacy/Strengths--These portable units allow real-time field monitoring for organic vapors. Some units are specifically calibrated for certain gases. Others allow a wide range of gas detection.

There are various sizes ranging from pocket size to briefcase size, with a variety of data logging and sample collection options. Detection limits can be as low as the ppb range.

EVALUATOR: D.P. Hoffmann Phone (615) 574-3896

REFERENCES: Vendor literature (MSA, Sensidyne, MDA, Andersen, Sentex, and Foxboro)

INEL PROBLEM SITES:

Radioactive underground, storage tanks, aboveground storage tanks, and associated soils.
OU 2-05, TRA-15.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 1-03, TSF-38, TSF-03.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 3-08, CPP-15; OU 5-12, PBF-10.

Radioactive spill areas, spill migrations, and unconfined disposal sites.
OU 3-08, CPP-36.

Unexploded navel ordnance.
OU 10-3, ORD.

Landfills.
OU 4-12, CFA-02, CFA-03.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Mixed low-level radioactive-metals, noncompactible, corrosive; Hazardous-organics, metals, recyclables; Low-level radioactive-noncompactible; Municipal-sanitary.

Waste Form/Contaminants:

Laboratory waste-liquids; Debris-glass, plastic; Soil; Concrete; Wood; Sludge; Lead chunks; Lead shot, bricks, batteries; Solid/Silver, mercury, plus radioisotopes, lead, ⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag, any metal or laboratory chemical, heavy hydrocarbons, Pb, chromium, trivalent chromium, fuel oil spills, metal, lead, lead oxide, plutonium at low levels, kerosene, tri-butyle phosphates, paint thinner, nitric acid, mercuric nitrate, beryllium, trichloroethane.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ characterization and monitoring

TECHNOLOGY: Field Portable X-Ray Fluorescence (FPXRF)

Fluorescence from the decay of elements excited by X-rays is used to obtain quantitative and qualitative elemental analyses of samples.

STATUS: Accepted

Support/Application Evaluation: Mechanical Host Disturbance
 Thermal Host Disturbance
 Liquid Host Disturbance
 High-Energy Host Disturbance
 Gas-Phase Host Disturbance

Temporal Areas of Evaluation: Pretreatment
 During Treatment
 Posttreatment

Deployment Evaluation: Manual Applications
 Automated Applications
 Robotic Applications

Driver Evaluation: Regulatory
 Risk Assessment
 Technical Assessment

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, Cr04,
 Hg, Pb,...)

SCIENCE AND TECHNOLOGY NEEDS:

This is a mature technology.

IMPLEMENTATION NEEDS:

This technology is mature for manual applications. It is an excellent candidate technology for automated or robotic deployment systems.

COMMENTS:

Amount of Waste Produced--None.

Overall Cost--The cost is approximately \$50K per unit and pennies per sample.

Efficacy/Strengths--It is portable, logs, data, and has an elemental range of Al to U. ppm levels are accepted by the EPA for Level I site assessment. It is a quick procedure (approximately 1 to 2 minutes per sample).

EVALUATOR: D.P. Hoffmann Phone (615) 574-3896.

REFERENCES: Vendor literature (Outokompu, HP)

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TAN V-1, TAN V-2, TAN V-3, TSF-PM2A, TSF-06; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-79; OU 3-08, CPP-27; OU 3-09, CPP-69; OU 3-12, CPP-81, CPP-82.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38, TSF-03, WRRTF-01; OU 1-04, LOFT-02; OU 2-07, TRA-36, TRA-39; OU 4-05, CFA-04, CFA-17; OU 4-06, CFA-06, CFA-43.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-07; OU 3-08, CPP-15; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06; OU 5-12, PBF-08, PBF-10; OU 7-13, RWMC-04.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 1-06, TSF-08; OU 3-08, CPP-29; OU 4-06, CFA-44.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-35, CPP-36; OU 3-09, CPP-03, CPP-08, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

Landfills.

OU-4-12, CFA-02, CFA-03.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible, corrosive, metals; Hazardous-organics, metals, recyclables; Radioactive, mixed radioactive, hazardous-organics, transuranic Rocky Flats fire waste, Pu, and fuel end boxes; Petroleum; Municipal-sanitary.

Waste Form/Contaminants:

Soil; Laboratory waste-liquid; Concrete; Liquid; Debris-paper, rags, sweepings, glass, plastic, vehicles, diatomaceous earth, wood, metal; Wood; Lead chunks; Lead shot, bricks, batteries; Sludge; Floor, asphalt/¹³⁷Cs, ¹³⁴Cs, ¹⁴⁴Cs, ⁶⁰Co, ⁹⁰Sr, ¹⁰⁶Ru, silver, mercury, plus radioisotopes, ⁵⁴Mn, ⁹⁷Nb, ¹⁵⁴Eu, ¹¹⁰Ag, low levels of Pu, Hg, mercuric nitrate, nitric acid, any metal, laboratory chemical, heavy hydrocarbons, Pb, lead, chromium, trivalent chromium, lead oxide, plutonium at low levels, kerosene, tri-butyle phosphates, ¹³⁷Cs and ¹³⁴Cs at 200mR/hr., ¹³⁷Cs, and ¹³⁴Cs at 2R/hr., TCE, toluene, carbon tetrachloride, paint thinner, No. 2 diesel fuel, fuel oil, and beryllium.

SUBELEMENTS: Characterization**ALTERNATIVES: Sampling****TECHNOLOGY: Microwave digestion**

Radiation in the microwave region is used to excite polar molecules to speed sample dissolution in closed systems.

STATUS: Accepted

Support/Application Evaluation: N/A

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, Cr04,
Hg, Pb,...)
Radioactive (abg)

SCIENCE AND TECHNOLOGY NEEDS:

This is an emerging technology that shows much promise in reducing the amount of waste produced in analyzing samples as well as increasing the quality of the data obtained.

IMPLEMENTATION NEEDS:

Instrumentation is needed as well as optimizing the digestion of concrete and soil matrices.

COMMENTS:

Amount of Waste Produced--Very low to none.

Overall Cost--Low capital cost

Efficacy/Strengths--It has the ability to digest and extract trace elements from soils and complex matrices before analysis. This is an emerging technology.

EVALUATOR: D.P. Hoffmann Phone (615) 574-3896

REFERENCES:

W.R. Kammin and M.J. Brandt, *Spectroscopy*, 1989, 4(3), P.49.

INEL PROBLEM SITES:

Located in General Section, Characterization, Volume 2. Common to all characterization activities.

PROBLEM AREAS/CONTAMINANTS: N/A

SUBELEMENTS: Characterization

ALTERNATIVES: Statistics/Modeling/Data Assessment

TECHNOLOGY: Artificial Intelligence/Neural Network

STATUS: Demonstration, testing and evaluation needed

Support/Application Evaluation: N/A

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications
Automated Applications
Robotic Applications

Driver Evaluation: Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Radioactive (abg)
Inorganic (U, Tc, Cr, Cr0-4,
Hg, Pb,...)
Organic (Oil, PCBs, VOCs,
TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:

There are many areas in which artificial intelligence could enhance not only the quality of the work performed but also allow the work being performed to be optimized on a more real-time basis.

IMPLEMENTATION NEEDS:

Software and model development will allow this powerful tool to be applied to the desired system.

Cost: Development \$100K, Capitol \$40 - 100K.

COMMENTS:

Amount of Waste Produced--N/A

Overall Cost--Approximately \$1K and up

Efficacy/Strengths--It allows control of instrumentation, data analysis, and interpretative analysis based upon human logic with the processing power and repetitive capabilities of computerized systems.

EVALUATOR: D.P. Hoffmann

Phone (615) 574-3896

REFERENCES:

S.D. Brown, R.S. Bear, Jr., and T.B. Blank, *Journal of Analytical Chemistry*, 64(12), 1992, p. 41R.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 2-05, TRA-15.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38, TSF-03.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 3-08, CPP-15.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 1-06, TSF-08.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-36.

Landfills.

OU 4-12, CFA-02, CFA-03.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Mixed low-level radioactive-metals, noncompactible, corrosive; Hazardous-organics, metals;
Low-level radioactive-noncompactible; Municipal-sanitary.

Waste Form/Contaminants:

Laboratory waste-liquid; Soil; Debris-glass, plastic; Sludge; Concrete; Solid/Silver, mercury, plus radioisotopes, ⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag, ⁶⁰Co, ¹³⁷Cs, any metal or laboratory chemical, heavy hydrocarbons, Pb, lead, fuel oil spills, Plutonium at low levels, kerosene, tri-butyle phosphates, chromium, paint thinner, nitric acid, mercuric nitrate, beryllium, trichloroethane.

SUBELEMENTS: Characterization

ALTERNATIVES: Laboratory characterization and analysis

TECHNOLOGY: Cold vapor (mercury) analysis

The absorption by ground-state mercury atoms when excited by a mercury-line source results in a decrease in the detected excitation energy and is related logarithmically to the number of mercury atoms in the light path.

STATUS: Accepted

Support/Application Evaluation: Mechanical Host Disturbance
 Thermal Host Disturbance
 Liquid Host Disturbance
 High-Energy Host Disturbance
 Gas-Phase Host Disturbance

Temporal Areas of Evaluation: Pretreatment
 During Treatment
 Posttreatment

Deployment Evaluation: Manual Applications
 Automated Applications

Driver Evaluation: Regulatory
 Risk Assessment
 Technical Assessment

Applicable Contaminant Evaluation: Inorganic (Hg)

SCIENCE AND TECHNOLOGY NEEDS:

This is a mature technology.

IMPLEMENTATION NEEDS:

This is a mature technology.

COMMENTS:

Amount of Waste Produced--Approximately 5 ml per sample.

Overall Cost--Approximately \$15K per unit

Efficacy/Strengths--It is automated, a mature technology, and EPA approved.

EVALUATOR: D.P. Hoffmann Phone (615) 574-3896

REFERENCES:

Vendor information (LDC Analytical, 1-800-532-4752)

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.
OU 2-05, TRA-15.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Mixed low-level radioactive.

Waste Form/Contaminants:

Laboratory waste-liquid/Silver, mercury, plus radioisotopes, ^{54}Mn , ^{97}Nb , ^{60}Co , ^{134}Cs , ^{144}Cs , ^{137}Cs , ^{90}Sr , ^{154}Eu , ^{110}Ag .

SUBELEMENTS: Characterization

ALTERNATIVES: In situ characterization and monitoring

TECHNOLOGY: Fiber optic chemical sensors

This technology uses specially coated fiber optic sensors which measure specific optical qualities which can be used to determine contamination levels.

STATUS: Demonstration, testing and evaluation needed

Support-Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance Obstructed/Limited Access	to
Host		
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment	
Deployment Evaluation:	Manual Applications Automated Applications Robotic Applications	
Driver Evaluation:	Risk Assessment Technical Assessment	

SCIENCE AND TECHNOLOGY NEEDS:

IMPLEMENTATION NEEDS:

COMMENTS:

Overall Cost--The cost is variable, approximately \$3K and up.

EVALUATOR: D.P. Hoffmann **Phone (615) 574-3896**

REFERENCES:

R.E. Dessey, *Journal of Analytical Chemistry*, 1989, 61(19), page 1079R.

INEL PROBLEM SITES:

Located in General Section, Characterization, Volume 2. Common to all characterization activities.

PROBLEM AREAS/CONTAMINANTS: N/A

SUBELEMENTS: Characterization

ALTERNATIVES: In situ characterization and monitoring

TECHNOLOGY: Laser scattering particle size analysis

Photographic, photometric, and electrometric techniques produce size measurement and distribution data for particulates in samples of powders and slurries.

STATUS: Accepted

Support/Application Evaluation: Mechanical Host Disturbance
Thermal Host Disturbance
Liquid Host Disturbance
High-Energy Host Disturbance
Gas-Phase Host Disturbance

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Radioactive (abg)
Inorganic (U, Tc, Cr, CrO₄,
Hg, Pb,...)

SCIENCE AND TECHNOLOGY NEEDS:

None, this is a mature technology.

IMPLEMENTATION NEEDS:

In situ devices need to be implemented for more aggressive IH/HP protection of personnel and to ensure the control (spread) of radioactive contamination.

COMMENTS:

Amount of Waste Produced--None to very little

Overall Cost--Approximately \$10K and up

Efficacy/Strengths--There are a variety of particle-size determinations on the market. This is a mature technology that can collect samples for particle-size distribution, and then allow further analysis to be performed on the collected material. There are several in situ, real-time monitoring devices, and the lower limit of detection is constantly being pushed back.

EVALUATOR: D.P. Hoffmann

Phone (615) 574-3896

REFERENCES: Vendor literature

INEL PROBLEM SITES:

Located in General Section, Characterization, Volume 2. Common to all characterization activities.

PROBLEM AREAS/CONTAMINANTS: N/A

SUBELEMENTS: Characterization

ALTERNATIVES: In situ characterization and monitoring

TECHNOLOGY: Hadamard masking for spatial resolution

STATUS: Demonstration, testing and evaluation needed

Support/Application Evaluation:

- Mechanical Host Disturbance
- Thermal Host Disturbance
- Liquid Host Disturbance
- High-Energy Host Disturbance
- Gas-Phase Host Disturbance

Temporal Areas of Evaluation:

- Pretreatment
- During Treatment
- Posttreatment

Deployment Evaluation:

- Manual Applications
- Automated Applications
- Robotic Applications

Driver Evaluation:

- Regulatory
- Risk Assessment
- Technical Assessment

Applicable Contaminant Evaluation:

- Inorganic (U, Tc, Cr, Cr04, Hg, Pb,...)
- Organic (Oils, PCBs, VOCs, TCE,...)
- Radioactive (abg)

SCIENCE AND TECHNOLOGY NEEDS:

Mask designs and collimators for specific applications are needed. We need to understand the scattering effects of using masks for radiation measurements.

IMPLEMENTATION NEEDS:

We need masks for adaptation of radiological counters for large area analysis.

Development Costs: \$200K.

COMMENTS:

Amount of Waste Produced--None

Overall Cost--Approximately \$1K and up

Efficacy/Strengths--It allows spatial resolution or multiplexing measurements to be made with a single-channel detector. This masking technology can allow a wide variety of techniques to obtain spatially resolved information with a higher signal-to-noise ratio than a standard single-point, limiting mask.

EVALUATOR: D.P. Hoffmann

Phone (615) 574-3896

REFERENCES:

D.P. Hoffmann; A. Proctor; and D.M. Hercules; 1989, *Appl. Spec.*, 43(6), pp. 899-907

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.
OU 2-05, TRA-15

Also located in General Section, Characterization, Volume 2.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Mixed low-level radioactive

Waste Form/Contaminants:

Laboratory waste-liquid/Silver, mercury, plus radioisotopes, ⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag

SUBELEMENTS: Characterization

ALTERNATIVES: Statistics/Modeling/Data assessment

TECHNOLOGY: Autocorrelation and optimized multivariate analysis

Mathematical models that enhance the information content of data by optimizing data collection and processing.

Liquid Scintillation Counting is a well-developed technology used for detection of low energy beta emitters such as tritium, carbon-14, phosphorous-32, technetium-99, and iodine-129. Samples are purified and the purified fraction is emulsified with a scintillation cocktail in a counting vial. The sample is then analyzed in a Liquid Scintillation Counter. The isotopes are identified by specific beta energy emissions and quantified based upon known efficiencies for the particular analysis type.

STATUS: Demonstration, testing and evaluation needed

Support/Application Evaluation: N/A

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, Cr04, Hg, Pb,...)
Organic (Oils, PCBs, VOCs, TCE,...)
Radioactive (abg)

SCIENCE AND TECHNOLOGY NEEDS:

We need to establish a data base of spectroscopic responses in support of D&D efforts.

IMPLEMENTATION NEEDS:

The software exists on site. We can tailor the software for direct programmatic applications.

COMMENTS:

Amount of Waste Produced--N/A

Overall Cost--\$1K and up

Efficacy/Strengths--It allows spectroscopic data to be analyzed and interpreted with minimum impact from noise. It allows the multivariate information to be fully analyzed. It increases computer searching abilities when comparing spectra with a large variation in spectral quality.

EVALUATOR: D.P. Hoffmann **Phone (615) 574-3896**

REFERENCES:

D.P. Hoffmann, A. Proctor, and D. M. Hercules; 1989, *Anal. Chem.*, 61(8), pp. 898-904.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TAN V-1, TAN V-2, TAN V-3, TSF-PM2A; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-31, CPP-79; OU 3-08, CPP-27.

Radioactive sumps, ponds, pits, trenches, etc.

OU 1-06, TSF-07; OU 3-08, CPP-15; OU 3-09, CPP-09; OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-36.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible, corrosive, metals; Radioactive, mixed radioactive, hazardous-organics, transuranic, Rocky Flats fire waste, Pu, and fuel end boxes.

Waste Form/Contaminants:

Debris-concrete, metals, paper, rags, sweepings, vehicles, diatomaceous earth, wood, glass; Soil; Concrete; Sludge; Floor; Asphalt/¹³⁷Cs, ¹³⁴Cs, ¹⁴⁴Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ¹⁵⁴Eu, ¹¹⁰Ag, ¹⁰⁶Ru, low levels of Pu, mercuric nitrate, nitric acid, Hg, Plutonium at low levels, kerosene, tri-butyle phosphates, ¹³⁷Cs and ¹³⁴Cs at 2R/hr., chromium, TCE, toluene, carbon tetrachloride, ¹³⁷Cs and ¹³⁴Cs at 200mR/hr.

SUBELEMENTS: Characterization

ALTERNATIVES: Laboratory characterization and analysis

TECHNOLOGY: X-Ray Diffraction (XRD)

This technology identifies the crystalline phases in solid samples by measuring the diffraction of x-rays.

STATUS: Accepted

Support/Application Evaluation:	Mechanical Host Disturbance
	Thermal Host Disturbance
	Liquid Host Disturbance
	High-Energy Host Disturbance
	Gas-Phase Host Disturbance

Temporal Areas of Evaluation:	Pretreatment
	During Treatment
	Posttreatment

Deployment Evaluation: Manual Applications
 Automated Applications

Driver Evaluation: Risk Assessment
 Technical Assessment

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO₄,
 Hg, Pb,...)
 Organic (Oils, PCBs, VOCs,
 TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:

This is a mature technology. Model studies of the complex mixtures of interest are needed if quantitative analysis is desired.

IMPLEMENTATION NEEDS:

None.

COMMENTS:

Amount of Waste Produced--None to 5 ml per sample

Overall Cost--High capital costs for equipment, \$100 and up per sample

Efficacy/Strengths--Phase identification of crystalline phases in solid samples. Approximately 1 wt% lower limit of detection. It can supply quantitative, stress/strain, and particle size information.

EVALUATOR: D.P. Hoffmann Phone (615) 574-3896

REFERENCES:

Materials Science Department, Martin Marietta Energy Systems, K-25 Site, Oak Ridge, TN,
37381-7272

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TAN V-1, TAN V-2, TAN V-3, TSF-PM2A; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-31, CPP-79; OU 3-08, CPP-27.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-06, TSF-07; OU 3-08, CPP-15; OU 3-09, CPP-09; OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-36.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible, corrosive, metals; Radioactive, mixed radioactive, hazardous-organics, transuranic, Rocky Flats fire waste, Pu, and fuel end boxes.

Waste Form/Contaminants:

Debris-concrete, metals, paper, rags, sweepings, vehicles, diatomaceous earth, wood, glass; Soil; Concrete; Sludge, Floor; Asphalt/¹³⁷Cs, ¹³⁴Cs, ¹⁴⁴Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ¹⁵⁴Eu, ¹¹⁰Ag, ¹⁰⁶Ru, low levels of Pu, mercuric nitrate, nitric acid, Hg, plutonium at low levels, kerosene, tri-butyle phosphates, ¹³⁷Cs and ¹³⁴Cs at 2R/hr., chromium, TCE, toluene, carbon tetrachloride, ¹³⁷Cs and ¹³⁴Cs at 200mR/hr.

SUBELEMENTS: Characterization**ALTERNATIVES: Laboratory characterization and analysis****TECHNOLOGY: Electron Diffraction (ED, SAED, LEED)**

This technology, when used in conjunction with transmission electron microscopy, provides phase identification of submicron particulate and impurities in a host matrix by measuring the electron diffraction.

STATUS: Accepted

Support/Application Evaluation: Mechanical Host Disturbance
Thermal Host Disturbance
Liquid Host Disturbance
High-Energy Host Disturbance
Gas-Phase Host Disturbance
Obstructed/Limited Access

Host

to

Temporal Areas of Evaluation: Pretreatment
 During Treatment
 Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Risk Assessment
 Technical Assessment
 Regulatory

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO₄,
 Hg, Pb,...)

SCIENCE AND TECHNOLOGY NEEDS:

None.

IMPLEMENTATION NEEDS:

None.

COMMENTS:

Amount of Waste Produced--None to 1 ml per sample

Overall Cost--High capital equipment costs

Efficacy/Strengths--When used in conjunction with transmission electron microscopy, it can provide phase identification of submicron particulates and impurities in a host matrix. It allows asbestos identification.

EVALUATOR: D.P. Hoffmann Phone (615) 574-3896

REFERENCES:

Materials Science Department, Martin Marietta Energy Systems, K-25 Site, Oak Ridge, TN,
37381-7272

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TAN V-1, TAN V-2, TAN V-3, TSF-PM2A, TSF-06; OU 3-07, CPP-26, CPP-28, CPP-79; OU 3-08, CPP-27; OU 3-12, CPP-81, CPP-82.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-07; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06, CPP-09; OU 5-12, PBF-08.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29, CPP-35, CPP-36; OU 3-09, CPP-03, CPP-08, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; Radioactive, mixed radioactive, hazardous-organics, transuranic, Rocky Flats fire waste, Pu, and fuel end boxes; Mixed low-level radioactive-noncompactible, corrosive, metals.

Waste Form/Contaminants:

Debris-concrete, metals, paper, rags, sweepings, vehicles, diatomaceous earth, wood, glass; Concrete; Sludge; Soil/¹³⁷Cs, ⁶⁰Co, ⁹⁰Sr, ¹⁰⁶Ru, ¹⁵⁴Eu, low levels of Pu, Hg, TCE, toluene, carbon tetrachloride, Pu, nitric acid, and, mercuric nitrate.

SUBELEMENTS: Characterization

ALTERNATIVES: Statistics/Modeling/Data assessment

TECHNOLOGY: Subsurface complexation

STATUS: Demonstration, testing and evaluation needed

Support/Application Evaluation: N/A

Temporal Areas of Evaluation: Pretreatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Radioactive (abg)
 Inorganic (U, Tc, Cr, Cr04,
 Hg, Pb,...)
 Organic (Oil, PCBs, VOCs,
 TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:

Models need to be implemented that take into account the geological formations that exist within the INEL.

IMPLEMENTATION NEEDS:

Same as above.

COMMENTS:

Amount of Waste Produced--N/A

Efficacy/Strengths--This modeling and our understanding of it will allow a more logical choice of decontamination technologies and an understanding of where contaminants may be located during environmental restoration activities.

EVALUATOR: D.P. Hoffmann Phone (615) 574-3896

REFERENCES:

D.L. Perry; Dialog File No. 265/266; ID No. 51826, ESD-60

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.
OU 2-05, TRA-15.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38, TSF-03, WRRTF-01; OU 1-04, LOFT-02; OU 2-07, TRA-36, TRA-39;
OU 4-05, CFA-04, CFA-17; OU 4-06, CFA-06, CFA-43.

Radioactive sumps, pond, pits, trenches, rubble piles, etc.

OU 3-08, CPP-15; OU 5-12, PBF-10.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 4-06, CFA-44.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-36.

Landfills.

OU 4-12, CFA-02.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Mixed low-level radioactive-metals, noncompactible, corrosive; Hazardous-organics, metals, recyclables; Low-level radioactive-noncompactible; Municipal-sanitary.

Waste Form/Contaminants:

Laboratory waste-liquid; Debris-glass, plastic; Soil; Concrete; Wood; Sludge; Lead shot, bricks, batteries; and, Solid/Silver, mercury, plus radioisotopes, ⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag, any metal or laboratory chemical, heavy hydrocarbons, Pb, lead, mercury, chromium, fuel oil spills, lead, lead oxide, plutonium at low levels, kerosene, tri-butyle phosphates, paint thinner, nitric acid, mercuric nitrate, beryllium, and trichloroethane.

SUBELEMENTS: Characterization

ALTERNATIVES: Laboratory characterization and analysis

TECHNOLOGY: Isotope Dilution Mass Spectrometry (IDMS)

A method for quantitative determination of concentrations of elemental species by incorporation in the sample of a standard that contains one or more isotopes of the element of interest.

STATUS: Accepted

Support/Application Evaluation:	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase Host Disturbance
Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications
Driver Evaluation:	Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Inorganic (U, Tc, Cr, CrO ₄ , Hg, Pb,...) Organic (Oil, PCBs, VOCs, TCE,...) Radioactive (abg)

SCIENCE AND TECHNOLOGY NEEDS:

Model studies are needed to enable quick analysis of U and Tc ratios to determine the extent of Tc that may be expected for various stages of the cascade equipment.

IMPLEMENTATION NEEDS:

Equipment is needed, as well as the model studies mentioned above.

COMMENTS:

Amount of Waste Produced--None to approximately 5 ml per sample

Overall Cost--High capital equipment costs

Efficacy/Strengths--It is able to measure the natural levels of long-lived fission products (Tc, I) and neutron-capture product (Pu) as low as 10^7 atoms.

EVALUATOR: D.P. Hoffmann Phone (615) 574-3896

REFERENCES:

D.B. Curtis; Dialog File No. 265/266; ID No. 25825; ERWE552C

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 3-08, CPP-27; OU 3-13, CPP-39.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38, TSF-03.

Radioactive sumps, ponds, pits, trenches, and unconfined disposal sites.

OU 3-13, CPP-48;

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-11, CPP-45.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Mixed low-level radioactive-noncompactible, corrosive, metals; Hazardous-corrosives, chemical, organics, metals; Low-level radioactive-noncompactible.

Waste Form/Contaminants:

Concrete; Soil; Debris-glass, plastics/⁹⁰Sr, ¹³⁷Cs, mercuric nitrate, nitric acid, hydrofluoric acid, any metal or laboratory chemical, heavy hydrocarbons, Pb, plutonium at low levels, kerosene, tri-butyle phosphates, nitric acid, aluminum nitrate.

SUBELEMENTS: Characterization**ALTERNATIVES: Laboratory characterization and analysis****TECHNOLOGY: Ion Chromatography (IC)**

This technology is used to determine anion or cation concentrations in aqueous samples or solid samples that have been converted to an aqueous form. Various column materials enable the chromatographic retention and subsequent elution (i.e., separation) of anions or cations. The anions or cations are then measured using various post column detectors. The appropriate combination of column material, eluent and detector is dependant on the anions or cations of interest and the matrix of the analytical sample.

STATUS: Accepted

Support/Application Evaluation:	Pretreatment
	During Treatment
	Posttreatment

Deployment Evaluation:	Manual Applications
	Automated Applications

Driver Evaluation: Risk Assessment
 Technical Assessment
 Regulatory

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, Cr04,
 Hg, Pb,...)

SCIENCE AND TECHNOLOGY NEEDS:

A detector system that is optimized for the expected waste streams that will be generated needed to be determined. This type of system can be used for process control of waste generation.

IMPLEMENTATION NEEDS:

We have systems available for process control of D&D efforts.

COMMENTS:

Amount of Waste Produced--None to 100 ml per sample

Overall Cost--Low capital equipment costs

Efficacy/Strengths--It has the ability to separate and quantify ions in solution (ppm to ppb detection limits depending upon the matrix effects). It can be automated and can perform in some on-line process applications.

EVALUATOR: D.P. Hoffmann Phone (615) 574-3896

REFERENCES:

P.R. Haddad; Dialog File No. 265/266; ID No. 25460

INEL PROBLEM SITES:

Radioactive, underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TAN V-1, TAN V-2, TAN V-3, TSF-PM2A, TSF-06; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-79; OU 3-08, CPP-27; OU 3-12, CPP-81, CPP-82.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-07; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06, CPP-09; OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29, CPP-35, CPP-36; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

Also located in General Section, Characterization, Volume 2.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible, corrosive, metals; Radioactive, mixed radioactive, hazardous-organic, transuranic, Rocky Flats fire waste, Pu, and fuel end boxes.

Waste Form/Contaminants:

Soil; Laboratory waste-liquid; Concrete; Sludge; Debris-paper, rags, sweepings, vehicles, diatomaceous earth, wood, metal, glass; Floor; Asphalt/¹³⁷Cs, ⁶⁰Co, ⁹⁰Sr, silver, mercury, plus radioisotopes, ⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹⁵⁴Eu, ¹¹⁰Ag, ¹⁰⁶Ru, low levels of Pu, Hg, ¹³⁷Cs and ¹³⁴Cs at 2R/hr., ¹³⁷Cs and ¹³⁴Cs at 200mR/hr., TCE, toluene, carbon tetrachloride, Pu; nitric acid, mercuric nitrate.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ characterization and monitoring

TECHNOLOGY: In situ measurement of beta gamma emitters

STATUS: Accepted

Support/Application Evaluation: N/A

Temporal Areas of Evaluation: Pretreatment
Posttreatment

Deployment Evaluation: Manual Applications

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.
OU 2-05, TRA-15.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Mixed low-level radioactive.

Waste Form/Contaminants:

Laboratory waste-liquid/Silver, mercury, plus radioisotopes, ^{54}Mn , ^{97}Nb , ^{60}Co , ^{134}Cs , ^{144}Cs , ^{137}Cs , ^{90}Sr , ^{154}Eu , ^{110}Ag .

SUBELEMENTS: Characterization

ALTERNATIVES: Sampling

TECHNOLOGY: Membrane technology for sample collection and concentration

For sample collection and concentration--membranes permeable predominantly to selected components in mixtures separate for accumulation or to facilitate analysis/detection.

STATUS: Demonstration, testing and evaluation needed

Support/Application Evaluation	Mechanical Host Disturbance Thermal Host Disturbance Liquid Host Disturbance High-Energy Host Disturbance Gas-Phase host Disturbance
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Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
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Deployment Evaluation:	Manual Applications Automated Applications Robotic Applications
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Driver Evaluation:	Risk Assessment Technical Assessment Regulatory
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INEL PROBLEM SITES:

Located in General Section, Characterization, Volume 2. Common to all characterization activities.

PROBLEM AREAS/CONTAMINANTS: N/A

SUBELEMENTS: Characterization

ALTERNATIVES: Sampling. In situ characterization/monitoring

TECHNOLOGY: Continuous Air Monitoring (CAM)

Apparatus designed to provide continuous sampling of air uses a variety of detection methods to identify and quantify components in the air stream.

STATUS: Accepted

Support/Application Evaluation: Mechanical Host Disturbance
Thermal Host Disturbance
Liquid Host Disturbance
High-Energy Host Disturbance
Gas-Phase Host disturbance

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications
Automated Applications
Robotic Applications

Driver Evaluation: Risk Assessment
Technical Assessment
Regulatory

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, Cr04,
Hg, Pb,...)
Radioactive (abg)
Organic (Oil, PCBs, VOCs,
TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:

This is a mature sampling technology.

IMPLEMENTATION NEEDS:

Low implementation costs.

COMMENTS:

Amount of Waste Produced--None to very little

Overall Cost--Low

Efficacy/Strengths--Optimizing the methods used for large-area or large-scale air monitoring will better allow characterization and monitoring studies to be performed. These studies will provide insight into the spread of contamination and how to best monitor for it.

EVALUATOR: D.P. Hoffmann Phone (615) 574-3896

REFERENCES: M.D. Hoover; Dialog File No. 265/266; ID No. 62466

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TSF-06; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-31, CPP-79; OU 3-08, CPP-27; OU 3-12, CPP-81, CPP-82.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-07; OU 3-08, CPP-15; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06, CPP-09; OU 5-12, PBF-08, PBF-10; OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29, CPP-35, CPP-36; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible, corrosive, metals; Radioactive, mixed radioactive, hazardous-organics, transuranic. Rocky Flats fire waste, Pu, and fuel end boxes.

Waste Form/Contaminants:

Debris-concrete, rags, paper, sweepings, vehicles, diatomaceous earth, wood, glass, metals; Soil; Concrete; Floor; Asphalt/¹³⁷Cs, ¹³⁴Cs, ¹⁴⁴Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ¹⁵⁴Eu, ¹¹⁰Ag, ¹⁰⁶Ru, low levels of Pu, mercuric nitrate, nitric acid, Hg, plutonium at low levels, kerosene, tri-butyle phosphates, chromium, TCE, toluene, carbon tetrachloride, Pu, ¹³⁷Cs and ¹³⁴Cs at 200mR/hr.

SUBELEMENTS: Characterization**ALTERNATIVES: Sampling****TECHNOLOGY: Vacuum assisted, reverse flow solvent extraction methods**

With this method, sampling is obtained by low-angle drilling through the host matrix to a point that is within the diffusion boundary of the porous media; Feeding a solvent into the drill hole; and using a vacuum device to pull the solvent through the uncontaminated matrix and collect the contaminant and solvent.

STATUS: Research and development needed**Support/Application Evaluation: N/A**

Temporal Areas of Evaluation: Pretreatment
 During Treatment
 Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Risk Assessment
 Technical Assessment

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, Cr04,
 Hg, Pb,...)
 Radioactive (abg)
 Organic (Oil, PCBs, VOCs,
 TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:

Model studies are needed.

IMPLEMENTATION NEEDS:

Model studies are needed.

COMMENTS:

Amount of Waste Produced--5-100 ml per sample

Overall Cost--Low

Efficacy/Strengths--In this method, sampling is obtained by low-angle drilling through the host matrix to a point that is within the diffusion boundary of the porous media; feeding a solvent into the drill hole; and using a vacuum device to pull the solvent through the contaminated matrix and collect the contaminant and solvent.

EVALUATOR: D.P. Hoffmann Phone (615) 574-3896

REFERENCES:

D.P. Hoffmann, ORNL, K-25 Site

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 3-07, CPP-26; OU 3-07, CPP-79.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; Hazardous-organics.

Waste Form/Contaminants:

Soil; Concrete/⁹⁰Sr, ¹³⁷Cs, ¹³⁴Cs, low levels of Pu, diesel fuel.

SUBELEMENTS: Characterization

ALTERNATIVES: Sampling

TECHNOLOGY: Multi-angle drilling for depth profiling of contaminants

STATUS: Demonstration, testing and evaluation needed

Support/Application Evaluation: N/A

Temporal Areas of Evaluation: Pretreatment
Posttreatment

Deployment Evaluation: Manual Applications
Robotic Applications

Driver Evaluation: Risk Assessment
Technical Assessment
Regulatory

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO₄,
Hg, Pb,...)
Radioactive (abg)
Organic (Oil, PCBs, VOCs,
TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:

Model studies need to be performed.

IMPLEMENTATION NEEDS:

Model studies need to be performed.

COMMENTS:

Amount of Waste Produced--Variable

Overall Cost--Low

Efficacy/Strengths--Although core drilling is a preferred technique to removal of a sample that remains spatially resolved, it is not always possible to do so. Multiangle drilling should allow a summation of depth artifacts to be determined through analysis of each sample collected. This system can utilize standard drilling equipment.

EVALUATOR: D.P. Hoffmann

Phone (615) 574-3896

REFERENCES:

D.P. Hoffmann, ORNL, K-25 Site

INEL PROBLEM SITES:

Located in General Section, Characterization, Volume 2. Common to all characterization activities.

PROBLEM AREAS/CONTAMINANTS:

N/A

SUBELEMENTS: Characterization

ALTERNATIVES: In situ physical

TECHNOLOGY: Annular Denuder Technology

STATUS: Accepted

No waste/low cost technology accepted for air sampling of contaminants. Could be coupled with automated measurement technology.

SCIENCE AND TECHNOLOGY NEEDS:

Development.

Need to develop technology for enhanced radiological sampling and analysis in the field.

IMPLEMENTATION NEEDS:

Development and equipment costs uncertain at the present <\$100/sample.

COMMENTS:

None.

EVALUATOR: D. P. Hoffmann Phone (615) 574-3896

REFERENCES:

F. W. Liberty, A. Febo, and M. Possanzini, NATO ASI Ser., 1988 252, p. 465.

INEL PROBLEM SITES:

Located in General Section, Characterization, Volume 2. Common to all characterization activities.

PROBLEM AREAS/CONTAMINANTS: N/A

SUBELEMENTS: Characterization

ALTERNATIVES: In situ characterization and monitoring

TECHNOLOGY: Small Long-Range Alpha Detector (LRAD)

STATUS: Demonstration, testing and evaluation needed

Support/Application Evaluation	Mechanical Host Disturbance Obstructed/Limited Access to Host
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Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
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Deployment Evaluation:	Manual Applications Automated Applications
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Driver Evaluation:	Regulatory Risk Assessment Technical Assessment
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Applicable Contaminant Evaluation:	Radioactive (abg)
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SCIENCE AND TECHNOLOGY NEEDS:

All types of D&D characterizations and cleanup certifications are needed.

IMPLEMENTATION NEEDS:

Suitable niche applications (viz-a-viz other passive alpha monitoring devices such as alpha track detectors and electrets) need to be identified. Cost: Implementation equipment \$2 - 3K, Operations \$20/Sample and Development \$100K.

COMMENTS:

Amount of Waste Produced--None

Overall Cost--\$10K per device

Efficacy/Strengths--It actively detects surfaces/objects contaminated at or below release limits. It measures ionized air drawn from a container holding a contaminated object, irrespective of shape.

EVALUATOR: Richard Gammage

Phone (615) 574-6256

REFERENCES: Los Alamos Publication, LA-12199-MS

WAVELENGTH DISPERSIVE X-RAY SPECTROSCOPY (WDS, WDX) CHAR 66-IN

INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 1-03, TSF-38, TSF-03.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 3-08, CPP-15.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Hazardous-organics, metals; Low-level radioactive-noncompactible.

Waste Form/Contaminants:

Debris-glass, plastic; Soil; Concrete/Any metal or laboratory chemical; heavy hydrocarbons, Pb, plutonium at low levels, kerosene, tri-butyle phosphates.

SUBELEMENTS: Characterization

ALTERNATIVES: Laboratory characterization and analysis

TECHNOLOGY: Wavelength Dispersive X-ray Spectroscopy (WDS, WDX)

STATUS: Accepted

Support/Application Evaluation:	Mechanical Host Disturbance
	Thermal Host Disturbance
	Liquid Host Disturbance
	High-Energy Host Disturbance
	Gas-Phase Host Disturbance

Temporal Areas of Evaluation:	Pretreatment
	During Treatment
	Posttreatment

Deployment Evaluation:	Manual Applications
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Driver Evaluation:	Risk Assessment
	Technical Assessment

Applicable Contaminant Evaluation:	Inorganic (U, Cr, CrO ₄ , Hg, Pb,...)
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SCIENCE AND TECHNOLOGY NEEDS:

Minimal. Site/problem specific.

IMPLEMENTATION NEEDS:

None.

COMMENTS:

Amount of Waste Produced--None to 5 ml per sample.

Overall Cost--High capital equipment costs.

Efficacy/Strengths--It allows rapid elementary analysis (Be and up) and quantitative analysis of solid samples. It is typically used in conjunction with electron microscopy. Although the detection limit is roughly 1 wt%, that is the detection limit of the area for the sample that is being probed. Thus, it is possible to analyze the individual materials that are present in the ppm range and lower.

EVALUATOR: D.P. Hoffmann

Phone (615) 574-3896.

REFERENCES:

Materials Science Department, Martin Marietta Energy Systems, K-25 Site, Oak Ridge, TN,
37381-7272

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TSF-06; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-31, CPP-79; OU 3-08, CPP-27; OU 3-12, CPP-81, CPP-82.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-07; OU 3-08, CPP-15; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06, CPP-09; OU 5-12, PBF-08, PBF-10; OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29, CPP-35, CPP-36; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible, corrosive, metals; Radioactive, mixed radioactive, hazardous-organics, transuranic, Rocky Flats fire waste, Pu, and fuel end boxes.

Waste Form/Contaminants:

Debris-concrete, rags, paper, sweepings, vehicles, diatomaceous earth, wood, glass, metals; Soil; Concrete; Floor; Asphalt/¹³⁷Cs, ¹³⁴Cs, ¹⁴⁴Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ¹⁵⁴Eu, ¹¹⁰Ag, ¹⁰⁶Ru, low levels of Pu, mercuric nitrate, nitric acid, Hg, plutonium at low levels, kerosene, tri-butyle phosphates, chromium, TCE, toluene, carbon tetrachloride, Pu, ¹³⁷Cs and ¹³⁴Cs at 200mR/hr.

SUBELEMENTS: Characterization**ALTERNATIVES: Sampling****TECHNOLOGY: Metallographic sample preparation**

This technology is a surface preparation, similar to polishing for metallic ceramic, and geological materials.

STATUS: Accepted

Support-Application Evaluation:	Mechanical Host Disturbance
	Thermal Host Disturbance
	Liquid Host Disturbance
	High-Energy Host Disturbance
	Gas-Phase Host Disturbance

Temporal Areas of Evaluation: Pretreatment
 During Treatment
 Posttreatment

Deployment Evaluation: Manual Applications
 Automated Applications
 Robotic Applications

Driver Evaluation: Risk Assessment

Applicable Contaminant Evaluation: Radioactive
 Inorganic (U, Tc, Cr, CrO₄,
 Hg, Pb, ...)

SCIENCE AND TECHNOLOGY NEEDS:

Procedure development for specific applications are needed; then protocols for standardized preparation should be developed.

IMPLEMENTATION NEEDS:

None. Facilities available (See also core drilling).

COMMENTS:

Amount of Waste Produced--~1 liter liquid and spent abrasive per 1-6 samples

Overall Cost--<\$500

Efficacy/Strengths--Provides representative sample showing contaminant depth distribution.

EVALUATOR: G.C. Marsh, ORNL

REFERENCES:

Technique is used routinely for preparation of metallic, ceramic, and geological materials.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TAN V-1, TAN V-2, TAN V-3, TSF-PM2A, TSF-06; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-79; OU 3-12, CPP-81, CPP-82.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38, TSF-03, WRRTF-01; OU 1-04, LOFT-02; OU 2-07, TRA-36, TRA-39; OU 4-05, CFA-04, CFA-17; OU 4-06, CFA-43.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-07; OU 3-08, CPP-15; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06, CPP-09; OU 5-12, PBF-08, PBF-10.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 1-06, LOFT-01; OU 4-06, CFA-44; OU 4-09, CFA-26, CFA-42.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-29, CPP-35, CPP-36; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-13, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

Landfills.

OU 4-12, CFA-02, CFA-03.

Also located in General Section, Characterization, Volume 2.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible; Hazardous-organics, metals; Municipal-sanitary.

Waste Form/Contaminants:

Debris-concrete, glass, plastic, metals; Soil; Laboratory waste-liquid; Any metal or laboratory chemical; Concrete; Wood; Sludge; Petroleum; Solid/¹³⁷Cs, ¹³⁴Cs, ¹⁴⁴Cs, ⁶⁰Co, ⁹⁰Sr, silver, mercury, plus radioisotopes, ⁵⁴Mn, ⁹⁷Nb, ¹⁵⁴Eu, ¹¹⁰Ag, low levels of Pu, heavy hydrocarbons, Pb, lead, mercury, chromium, trivalent chromium, fuel oil spills, Hg, diesel fuel, lead, paint thinner, No. 2 diesel fuel, beryllium, trichloroethane, plutonium at low levels, kerosene, tri-butyle phosphates.

SUBELEMENTS: Characterization

ALTERNATIVES: Sampling

TECHNOLOGY: Optimization of Sampling Designs

Research and development into the statistical aspects of sampling such diverse, extensive media.

STATUS: Demonstration, testing and evaluation needed

Support/Application Evaluation: N/A

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications
Automated Applications
Robotic Applications

Driver Evaluation: Regulatory
Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Radioactive (abg)
Inorganic (U, Tc, Cr, Cr04,
Hg, Pb,...)
Organic (Oil, PCBs, VOCs,
TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:

Literary searches for finding useful sampling designs from investigations in other fields. New statistical methods for sampling design.

IMPLEMENTATION NEEDS:

Normal

COMMENTS:

Efficacy/Strengths--Appropriate sampling designs can prevent obtaining too little information when sampling is complete or spending too much money on a more than adequate number of samples.

EVALUATOR: J.L. Bock, ORNL

REFERENCES:

ORNL, K-25 Site Statistical Services

INEL PROBLEM SITES:

Located in General Section, Characterization, Volume 2. Common to all characterization activities.

PROBLEM AREAS/CONTAMINANTS: N/A

SUBELEMENTS: Characterization

ALTERNATIVES: Data management

TECHNOLOGY: Database Management for Large Data Collection

Brings together data base management procedures and software that will effectively manage the data produced from a full-scale D&D effort.

STATUS: Accepted

Support/Application Evaluation: N/A

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications
Automated Applications
Robotic Applications

Driver Evaluation: Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Radioactive (abg)
Inorganic (U, Tc, Cr, Cr04,
Hg, Pb,...)
Organic (Oil, PCBs, VOC,
TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:

Data management procedures and techniques need to be found or developed that will readily allow for statistical manipulation and visual display of large quantities of data. Procedures will need to be developed to ensure the integrity of the data. This is extremely important when modifications and additions to the database could come from many different sources.

IMPLEMENTATION NEEDS:

Normal

COMMENTS:

Efficacy/Strengths--Generating large amounts of data is useless unless the data are reliable and there are ways to readily make use of it.

EVALUATOR: J.L. Bock, ORNL

REFERENCES:

Geodata Group, Martin Marietta Energy Systems Engineering, K-25 Statistical Services, ORNL, Oak Ridge, TN, 37381

INEL PROBLEM SITES:

Located in General Section, Characterization, Volume 2. Common to all characterization activities.

PROBLEM AREAS/CONTAMINANTS: N/A

SUBELEMENTS: Characterization

ALTERNATIVES: N/A

TECHNOLOGY: Visual Display Of Statistical Information

Incorporation of currently available and soon-to-be available visualization software with the D&D database.

STATUS: Demonstration, testing and evaluation needed

Support/Application Evaluation: N/A

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications
Automated Applications
Robotic Applications

Driver Evaluation: Risk Assessment

Applicable Contaminant Evaluation: Radioactive (abg)
Inorganic (U, Tc, Cr, Cr04,
Hg, Pb,...)
Organic (Oil, PCBs, VOCs,
TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:

We need integration of statistics software and a database system with graphic display capabilities. Currently a Geographic Information System (GIS) comes the closest to meeting this need. New techniques for graphic data display may need to be developed to aid scientists and regulators in their understanding of complex contamination scenarios.

IMPLEMENTATION NEEDS:

Normal

COMMENTS:

None.

EVALUATOR: J.L. Bock, ORNL

REFERENCES: ORNL, K-25 Site Statistical Services

INEL PROBLEM SITES:

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 3-09, CPP-09.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-09, CPP-10.

Also located in General Section, Characterization, Volume 2.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible.

Waste Form/Contaminants:

Soil; Concrete/¹³⁷Cs, ¹³⁴Cs, ⁹⁰Sr, ¹³⁷Cs and ¹³⁴Cs at 2R/hr.

SUBELEMENTS: Characterization

ALTERNATIVES: Modeling/Data Assessment/Statistics

TECHNOLOGY: Statistical Methods for Spatially Correlated Data

Research and development of geostatistical techniques and methods in the D&D arena.

STATUS: Accepted

Support-Application Evaluation: N/A

Temporal Areas of Evaluation: Pretreatment
Posttreatment

Deployment Evaluation: Manual Applications
Automatic Applications
Robotic Applications

Driver Evaluation: Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Radioactive (abg)
Inorganic (U, Tc, Cr, Cr04,
Hg, Pb,...)
Organic (Oil, PCBs, VOCs,
TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:

Easy-to-use kriging software will need to be found or developed.

IMPLEMENTATION NEEDS:

Normal

COMMENTS:

Efficacy/Strengths--The use of spatial statistics and kriging (geostatistics) has been demonstrated successfully for a number of years in the mining and petroleum industries.

EVALUATOR: J. L. Bock, ORNL

REFERENCES:

ORNL, K-25 Site Statistical Services

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.
OU 2-05, TRA-15.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 1-03, TSF-38, TSF-03.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 3-08, CPP-15.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.
OU 4-06, CFA-44.

Radioactive spill areas, spill migrations, and unconfined disposal sites.
OU 3-08, CPP-36.

Unexploded navel ordnance.
OU 10-03, ORD.

Landfills.
OU 4-12, CFA-02, CFA-03.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Mixed low-level radioactive-noncompactible, metals, corrosive; Hazardous-organics, metals, recyclables; Low-level radioactive-noncompactible; Municipal-sanitary.

Waste Form/Contaminants:

Laboratory waste-liquid; Debris-glass, plastic; Soil; Concrete; Wood; Sludge; Lead chunks; Lead shot, bricks, batteries; Solid/Silver, mercury, plus radioisotopes, ⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag, any metal or laboratory chemical, heavy hydrocarbons, Pb, lead, mercury, chromium, trivalent chromium, fuel oil spills, lead, lead oxide, plutonium at low levels, kerosene, tri-butyle phosphates, paint thinner, nitric acid, mercuric nitrate, beryllium, trichloroethane.

SUBELEMENTS: Characterization

ALTERNATIVES: Laboratory characterization and analysis

TECHNOLOGY: Atomic absorption spectroscopy (AA, AE)

Atomic spectroscopy is a technology used to determine single metal concentrations in solutions. This is accomplished by the measurement of atomic emission by an optical spectroscopic technique. Atomic absorption (AA) and atomic emission (AE) spectroscopies are based on the unique absorbance or emission properties of metals when thermally excited to the atomic state.

In AA, metals are atomized by exposure to thermal energy (flame or furnace), the atomic species are exposed to a narrow wavelength light source and changes in the light source and changes in the light source energy are detected by a photo multiplier tube. The amount of light absorbed by the atomic species at a characteristic wavelength is proportional to the concentration of the element with AE. the thermal energy source is flame and the atomized species emit light at characteristic wavelengths. the intensity of the emitted light is measured and is proportional to the concentration of the element.

STATUS: Accepted

Support/Application Evaluation: Mechanical Host Disturbance
 Thermal Host disturbance
 Liquid Host Disturbance
 High-Energy Host Disturbance
 Gas-Phase Host Disturbance

Temporal Areas of Evaluation: Pretreatment
 During Treatment
 Posttreatment

Deployment Evaluation: Manual Applications
 Automated Applications

Driver Evaluation: Risk Assessment
 Technical Assessment
 Regulatory

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO₄,
 Hg, Pb,...)

SCIENCE AND TECHNOLOGY NEEDS:

The technology is well-developed and applicable as is.

IMPLEMENTATION NEEDS:

Technology is available at the ORNL K-25 Site.

COMMENTS:

Amount of Waste Produced--Very small quantities (<10 ml) of aqueous waste

Overall Cost--\$25-\$50 per metal determined

Efficacy/Strengths--It is a standard, well-accepted methodology for highly-sensitive and selective determination of single metals.

EVALUATOR: J.R. Stokely, ORNL

REFERENCES:

EPA regulations; Office of Solid Waste (SW-846), EPA CLP SOW 88k ASTM methods.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.
OU 2-05, TRA-15.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 1-03, TSF-38, TSF-03.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 3-08, CPP-15.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.
OU 4-06, CFA-44.

Radioactive spill areas, spill migrations, and unconfined disposal sites.
OU 3-08, CPP-36.

Landfills.
OU 4-12, CFA-02, CFA-03

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Mixed low-level radioactive-metals, noncompactible, corrosive; Hazardous-organics, metals, recyclables; Low-level radioactive-noncompactible; Municipal-sanitary.

Waste Form/Contaminants:

Laboratory waste-liquid; Debris-glass, plastic; Soil; Concrete; Wood; Sludge; Lead chunks; Lead shot, bricks, batteries; Solid/Silver, mercury, plus radioisotopes, ⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag, any metal or laboratory chemical, heavy hydrocarbons, Pb, lead, mercury, chromium, trivalent chromium, fuel oil spills, lead oxide, plutonium at low levels, kerosene, tri-butyle phosphates, paint thinner, nitric acid, mercuric nitrate, beryllium, trichloroethane.

SUBELEMENTS: Characterization**ALTERNATIVES: Laboratory characterization and analysis****TECHNOLOGY: Inductively coupled plasma spectroscopy (ICP)**

Inductively coupled plasma atomic emission spectroscopy (AES) is a technology for the simultaneous or sequential multi-element determination of trace elements in solution. This is accomplished by the measurement of atomic emission by an optical spectroscopic technique. Aqueous solutions are introduced to a thermal energy source (radio frequency inductively coupled plasma) where the elements are atomized resulting in a characteristic atomic-line emission spectra. The spectra are dispersed by a grating spectrometer and the intensities detected by photomultiplier tubes. Several elements may be determined simultaneously using this technique.

STATUS: Accepted

Support/Application Evaluation: Mechanical Host Disturbance
Thermal Host Disturbance
Liquid Host Disturbance
High-Energy Host Disturbance
Gas-Phase Host Disturbance

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications
Automated Applications

Driver Evaluation: Risk Assessment
Technical Assessment
Regulatory

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO₄,
Hg, Pb,...)

SCIENCE AND TECHNOLOGY NEEDS:

It is applicable as is. This is a well-developed technology.

IMPLEMENTATION NEEDS:

It is available at K-25 Site.

COMMENTS:

Amount of Waste Produced--Small quantities (<10 ml) of aqueous waste.

Overall Cost--\$100-\$150 per multi-element analysis of metals

Efficacy/Strengths--It is a standard, well-accepted methodology. It allows multi-element analyses (up to 50 elements).

EVALUATOR: J.R. Stokely, ORNL

REFERENCES:

EPA regulations, Office of Solid Waste (SW 846), EPA CLP SOW 88, ASTM Methods Manuals

INDUCTIVELY COUPLED PLASMA-MASS SPECTROSCOPY (ICP-MS) CHAR 78-IN

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 2-05, TRA-15.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38, TSF-03.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 3-08, CPP-15; OU 5-12, PBF-10.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-36

Landfills.

OU 4-12, CFA-02, CFA-02.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Mixed low-level radioactive-metals, noncompactible, corrosive; Hazardous-organics, metals, recyclables; Low-level radioactive-noncompactible; Municipal-sanitary.

Waste Form/Contaminants:

Laboratory waste-liquid; Debris-glass, plastic; Soil; Concrete; Wood; Sludge; Lead chunks; Lead shot, bricks, batteries; Solid/Silver, mercury, plus radioisotopes, ⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag, any metal or laboratory chemical, heavy hydrocarbons, Pb, lead, chromium, trivalent chromium, fuel oil spills, lead, lead oxide, plutonium at low levels, kerosene, tri-butyle phosphates, paint thinner, nitric acid, mercuric nitrate, beryllium, trichloroethane.

SUBELEMENTS: Characterization

ALTERNATIVES: Laboratory characterization and analysis

TECHNOLOGY: Inductively coupled plasma, Mass spectroscopy (ICP-MS)

Samples are introduced into a high energy plasma which desolvates, dissociates, and excites the species in the sample. Ions generated in the plasma are directed into a mass selective detector where they are separated by mass to charge ratio. Ions of the selected mass/charge ratio are directed to a detector which quantifies the number of ions present. Isotopic as well as elemental information may be obtained.

STATUS: Demonstration

INDUCTIVELY COUPLED PLASMA-MASS SPECTROSCOPY (ICP-MS) CHAR 78-IN

Support/Application Evaluation: Mechanical Host Disturbance
 Thermal Host Disturbance
 Liquid Host Disturbance
 High-Energy Host Disturbance
 Gas-Phase Host Disturbance

Temporal Areas of Evaluation: Pretreatment
 During Treatment
 Posttreatment

Deployment Evaluation: Manual Applications
 Automated Applications

Driver Evaluation: Risk Assessment
 Technical Assessment

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO₄,
 Hg, Pb,...)

SCIENCE AND TECHNOLOGY NEEDS:

It is applicable as is for multi-element analysis of aqueous solutions. Development is in progress to use the technology for surface analysis using laser ablation techniques.

IMPLEMENTATION NEEDS:

It is now or soon will be available at the K-25 Site. It is available at ORNL.

COMMENTS:

Amount of Waste Produced--Small quantities (<10 ml) of aqueous waste

Overall Cost--\$100-\$200 per multi-element analysis for metals

Efficacy/Strengths--It has multi-element capability. It is more selective than ICP/AES. It can perform isotopic analysis.

EVALUATOR: J.R. Stokely, ORNL

REFERENCES:

In-house methods, literature publications.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.

OU 1-05, TAN V-1, TAN V-2, TAN V-3, TSF-PM2A, TSF-06; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-79; OU 3-08, CPP-27; OU 3-09, CPP-69; OU 3-12, CPP-81, CPP-82; OU 3-13, CPP-39.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38, TSF-03, WRRTF-01; OU 1-04, LOFT-02; OU 2-07, TRA-36, TRA-39; OU 4-05, CFA-04, CFA-17; OU 4-06, CFA-06, CFA-43.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-07; OU 3-08, CPP-15; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06, CPP-09; OU 3-13, CPP-48; OU 5-12, PBF-05, PBF-10; OU 7-13, RWMC-04.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 1-06, LOFT-01, TSF-08; OU 3-11, CPP-45; OU 4-06, CFA-44; OU 4-09, CFA-10, CFA-26, CFA-42.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29, CPP-35, CPP-36; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

Landfills:

OU 4-12, CFA-02, CFA-03.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Low-level radioactive-noncompactible, liquid; Mixed low-level radioactive-noncompactible, corrosive, metals; Hazardous-corrosive, chemical, organics, metals; Radioactive, mixed radioactive, hazardous-organic, transuranic, Rocky Flats fire waste, Pu, and fuel end boxes; Petroleum; Municipal-sanitary.

Waste Form/Contaminants:

Soil; Laboratory waste-liquid; Concrete; Liquid; Debris-paper, rags, sweepings, vehicles, diatomaceous earth, metal, glass, plastic; Wood; Sludge; Gravel; Floor; Asphalt/¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁶⁰Co, ⁹⁰Sr, silver, mercury, plus radioisotopes, ⁵⁴Mn, ⁹⁷Nb, ¹⁵⁴Eu, ¹¹⁰Ag, ¹⁰⁶Ru, ¹⁵⁴Eu, low levels of Pu, mercuric nitrate, nitric acid, hydrofluoric acid, any metal or laboratory chemical, heavy hydrocarbons, Pb, lead, mercury, chromium, trivalent chromium, fuel oil spills, lead oxide, Hg, plutonium at low levels, kerosene, tri-butyle phosphates, ¹³⁷Cs, and ¹³⁴Cs at 2R/hr., TCE, toluene, carbon tetrachloride, diesel fuel, ¹³⁷Cs and ¹³⁴Cs at 200mR/hr., aluminum nitrate, paint thinner, PCB spill, No. 2 diesel fuel, fuel oil, beryllium, and trichloroethane.

SUBELEMENTS: Characterization

ALTERNATIVES: Sampling

TECHNOLOGY: Sampling and mixing methods

STATUS: Demonstration, testing and evaluation needed

Support/Application Evaluation: N/A

Temporal Areas of Evaluation: Pretreatment
Posttreatment

Deployment Evaluation: Manual Application

Driver Evaluation: Technical Assessment/Risk

Applicable Contaminant Evaluation: Radioactive (abg)
Inorganic (U, Tc, Cr, Cr04,
Hg, Pb,...)
Organic (Oil, PCBs, VOCs,
TCE,...)

SCIENCE AND TECHNOLOGY NEEDS: Methods of collecting representative samples and mixing samples into a homogeneous state need to be optimized.

IMPLEMENTATION NEEDS: Requires statistical sampling design and proper laboratory blenders, mixer, and other equipment.

COMMENTS:

Amount of waste produced--none.

EVALUATOR: J.S. Watson

Phone (615) 576-6297

REFERENCES:

No references provided in ORNL TLD for K-25.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TSF-06; OU 3-07, CPP-26, CPP-28, CPP-79; OU 3-08, CPP-27; OU 3-12, CPP-81, CPP-82.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-07, OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06, CPP-09; OU 5-12, PBF-08; OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29, CPP-35, CPP-36; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22; OU 3-11, CPP-58; OU 3-12, CPP-78, CPP-80.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible, corrosive, metals; Radioactive, mixed radioactive, hazardous-organic, transuranic Rocky Flats fire waste, Pu, fuel end boxes.

Waste Form/Contaminants:

Soil; Concrete; Sludge; Debris-paper, rags, sweepings, vehicles, diatomaceous earth, wood, metal, glass; Floor, Asphalt/¹³⁷Cs, ¹³⁴Cs, ⁶⁰Co, ⁹⁰Sr, ¹⁰⁶Ru, ¹⁵⁴Eu, low levels of Pu, mercuric nitrate, nitric acid, Hg, TCE, toluene, carbon tetrachloride, Pu, ¹³⁷Cs, and ¹³⁴Cs at 2R/hr., ¹³⁷Cs and ¹³⁴Cs at 200mR/hr.

SUBELEMENTS: Characterization

ALTERNATIVES: Sampling

TECHNOLOGY: Punch cores

STATUS: Accepted

Support/Application Evaluation: N/A

Temporal Areas of Evaluation: Pretreatment

Deployment Evaluation: Manual Application

Driver Evaluation: Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Radioactive (abg)
Inorganic (U, Tc, Cr, Cr04,
Hg, Pb,...)
Organic (Oil, PCBs, VOC,
TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:

Commercial instrumentation available.

IMPLEMENTATION NEEDS:

Developmental cost, \$100K.

COMMENTS:

Amount of Waste Produced--Minimum

EVALUATOR: J.S. Watson, ORNL

REFERENCES:

No information provided in the ORNL TLD for K-25.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TSF-06; OU 3-07, CPP-26, CPP-28, CPP-79; OU 3-08, CPP-27; OU 3-12, CPP-81, CPP-82.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-07; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06, CPP-09; OU 5-12, PBF-08.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29, CPP-35, CPP-36; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible, corrosive, metals.

Waste Form/Contaminants:

Soil; Concrete; Sludge; Floor; Asphalt/¹³⁷Cs, ¹³⁴Cs, ⁶⁰Co, ⁹⁰Sr, ¹⁰⁶Ru, ¹⁵⁴Eu, low levels of Pu, mercuric nitrate, nitric acid, Hg, ¹³⁷Cs and ¹³⁴Cs at 2R/hr., ¹³⁷Cs and ¹³⁴Cs at 200mR/hr.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ characterization and monitoring

TECHNOLOGY: Laser ablation for diagnosing metals and radionuclides

This technology consists of using a laser to vaporize a layer of a solid material. The vaporized layer may then be analyzed for metals and/or radionuclides. This technology may also be used for depth profiling.

STATUS: Demonstration, testing and evaluation needed

Support/Application Evaluation:	N/A
Temporal Areas of Evaluation:	N/A
Deployment Evaluation:	N/A
Driver Evaluation:	N/A
Applicable Contaminant Evaluation:	N/A

SCIENCE AND TECHNOLOGY NEEDS:

Technology for laser ablation is just now becoming available, and a program would be needed to develop the technique for practice of application of the analysis.

IMPLEMENTATION NEEDS: Coupling to appropriate detectors.

COMMENTS:

Amount of Waste Produced--

Overall Cost--\$200K

Efficacy/Strengths--Technique could be used to sample and analyze solid materials by ablating away the surface, followed by analysis of the removed material.

EVALUATOR: M.R. Cates

Phone (615) 574-8056

REFERENCES: No references in ORNL TLD for K-25.

Temporal Areas of Evaluation:	Pretreatment During Treatment Posttreatment
Deployment Evaluation:	Manual Applications Automated Applications
Driver Evaluation:	Regulatory Risk Assessment Technical Assessment
Applicable Contaminant Evaluation:	Organic (Oil, PCBs, VOCs, TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:

Technology is applicable as is. Benefit would be derived from faster chromatography to shorten analysis time.

IMPLEMENTATION NEEDS:

Technology is available at the K-25 Site.

COMMENTS:

Amount of Waste Produced--Near zero for volatiles; approximately 10 ml per sample organic extract

Overall Cost--\$200-\$400 per sample for volatiles; \$400-\$800 per sample for semi-volatiles; \$200-\$600 for PCBs

Efficacy/Strengths--Standard EPA-accepted methods exist. It is useful for chemical identification and confident quantitation.

EVALUATOR: M.R. Guerin, ORNL

REFERENCES:

EPA regulations; the Office of Solid Waste (SW-846) Methods Compendium

INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38, TSF-03.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 3-08, CPP-15; OU 7-13, RWMC-04

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 7-08, RI/FS.

Landfills.

OU 4-12, CFA-02, CFA-03.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Hazardous-organics, metals; Low-level radioactive-noncompactible; Radioactive, mixed radioactive, hazardous-organic, transuranic, Rocky Flats fire waste and fuel end boxes; Municipal-sanitary.

Waste Form/Contaminants:

Debris-glass, plastic, paper, rags, sweepings, vehicles, diatomaceous earth, wood, metal; Soil; Concrete; Sludge; Liquid; Solid/Any metal or laboratory chemical, heavy hydrocarbons, Pb, plutonium at low levels, kerosene, tri-butyle phosphates, ⁶⁰Co, TCE, toluene, carbon tetrachloride, Pu, lead, paint thinner, chloroform, chromium, mercury, beryllium, trichloroethane.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ characterization and monitoring

TECHNOLOGY: Direct Sampling Ion Trap Mass Spectrometry (DSITMS)

This real time technology obtains qualitative and quantitative data by correlating masses detected with the ions present.

STATUS: Demonstration, testing and evaluation needed

Support/Application Evaluation:	Mechanical Host Disturbance
	Thermal Host Disturbance
	Liquid Host Disturbance
	High-Energy Host Disturbance
	Gas-Phase Host Disturbance
	Obstructed/Limited Access
	to Host

Temporal Areas of Evaluation: Pretreatment
 During Treatment
 Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Risk Assessment
 Technical Assessment

Applicable Contaminant Evaluation: Organic (oil, PCBs, VOCs,
 TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:

Methods need to be developed for specific applications.

IMPLEMENTATION NEEDS:

Hardware (\$100K) and personnel are needed for development, training, and implementation.

COMMENTS:

Amount of Waste Produced--None

Overall Cost--It is application-specific

Efficacy/Strengths--It allows rapid (<5 min) determination of organics, continuous air monitoring, and possible real-time surface analysis.

This technology is under development at ORNL. It was exported to the Savannah River Laboratory, and it is being considered for Hanford and Martin Marietta Energy Systems deployment.

EVALUATOR: M.R. Guerin, ORNL

REFERENCES:

R. G. Cooks, G. L. Glish, S. A. McLuckey, and R. E. Kaiser, "Ion Trap Mass Spectrometry," *C&EN*, 26-41, March 1991.

M. B. Wise, G. B. Hurst, C. V. Thompson, M. V. Buchanan, and M. R. Guerin, "Screening Volatile Organics by Direct Sampling Ion Trap and Glow Discharge Mass Spectrometry", Proceedings of the 2nd International Symposium on Field Screening for Hazardous Wastes and Toxic Chemicals, Life Sciences, Cleveland, OH, February, 1991, pp. 273-288.

M. R. Guerin, M. B. Wise, C. V. Thompson, and M. V. Buchanan, "Rapid Characterization and Monitoring by direct Sampling Ion Trap Mass Spectrometry", Oak Ridge National Laboratory Document, ORNL-DWG89M-19153.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TAN V-1, TAN V-2, TAN V-3, TSF-06, TSF-PM2A; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-31, CPP-79; OU 3-08, CPP-27.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-06, TSF-07; OU 3-09, CPP-09; OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-36.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Low-level radioactive-noncompactible, corrosive, metals; Radioactive, mixed radioactive, hazardous-organics, transuranic, Rocky Flats fire waste, Pu, fuel end boxes.

Waste Form/Contaminants:

Debris-Concrete, metals, rags, sweepings, paper, vehicles, diatomaceous earth, wood, glass; Soil; Concrete; Sludge; Floor; Asphalt/¹³⁷Cs, ¹³⁴Cs, ¹⁴⁴Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ¹⁵⁴Eu, ¹¹⁰Ag, ¹⁰⁶Ru, low levels of Pu, mercuric nitrate, nitric acid, Hg, plutonium at low levels, kerosene, tri-butyle phosphates, ¹³⁷Cs and ¹³⁴Cs at 2R/hr.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ characterization and monitoring

TECHNOLOGY: Fluorescence

This technology uses light as a means of detecting a chemical species. Excess energy is put into a chemical species so it gives off a fluorescence that are characteristic of that particular species.

STATUS: Demonstration, testing and evaluation needed.

Support/Application Evaluation: N/A

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: N/A

Applicable Contaminant Evaluation: Organic (Oil, PCBs, VOCs,
TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:

The technology is somewhat established, but specific compounds to be detected must be tested with another method before deployment, which is not routine.

IMPLEMENTATION NEEDS:

Hardware needs to be procured and conditions established for the specific compounds of interest.

COMMENTS:

Amount of Waste Produced--None

Overall Cost--Moderate (<\$100 per sample)

Efficacy/Strengths--It can be tuned to monitor specific classes of compounds. Note: We can do this without a laser for in situ monitoring. The laser system needs further development.

EVALUATOR: M.V. Buchanan, ORNL

REFERENCES:

None provided. For additional information, contact the above evaluator.

INEL PROBLEM SITES:

Radioactive underground, storage tanks, aboveground storage tanks, and associated soils.

OU 2-05, TRA-15.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38, TSF-03,

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-36.

Unexploded navel ordnance.

OU 10-03, ORD.

Landfills.

OU 4-12, CFA-02, CFA-03.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Mixed low-level radioactive-metals, noncompactible, corrosive; Hazardous-organics, metals, recyclables; Low-level radioactive-noncompactible; Municipal-sanitary.

Waste Form/Contaminants:

Laboratory waste-liquids; Debris-glass, plastic; Soil; Concrete; Wood; Sludge; Lead chunks; Lead shot, bricks, batteries; Solid/Silver, mercury, plus radioisotopes, lead, ⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag, any metal or laboratory chemical, heavy hydrocarbons, Pb, chromium, trivalent chromium, fuel oil spills, metal, lead, lead oxide, plutonium at low levels, kerosene, tri-butyle phosphates, paint thinner, nitric acid, mercuric nitrate, beryllium, trichloroethane.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ characterization and monitoring

TECHNOLOGY: X-ray fluorescence for in situ monitoring of toxic heavy metals

This technology consists of using fluorescence from the decay of elements excited by x-rays to obtain quantitative and qualitative elemental analysis of samples.

STATUS: Accepted

Support/Application Evaluation: N/A

Temporal Areas of Evaluation: Pretreatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Risk Assessment
Technical Assessment
Regulatory

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, Cr04,
Hg, Pb,...)

SCIENCE AND TECHNOLOGY NEEDS:

There are a variety of situations involving surfaces contaminated with heavy metals.

IMPLEMENTATION NEEDS:

We need to evaluate substrate effects from different surfaces for magnitude and prevalence of false positives and negatives. Both room temperature or liquid nitrogen cooled XRF monitors are available commercially for testing and matching to K-25.

COMMENTS:

Amount of Waste Produced--None

Overall Cost--\$15K per XRF

Efficacy/Strengths--This technology is already in use in HUD and EPA programs to detect Pb paints. Measuring devices are commercially available for analyzing homogenized samples for heavy elements or detecting heavy metals in situ on surfaces. It was evaluated in the EPA Site Program.

EVALUATOR: R.B. Gammage Phone (615) 574-6256

REFERENCES:

Many publications and user courses are available. HASRD (ORNL) is implementing XRF in HUD lead in paint programs. Contact Richard Gammage or David Wilson, HASRD/ORNL, at (615) 574-6256 or (615) 576-7607.

INEL PROBLEM SITES:

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 4-09, CFA-100.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Hazardous-organics.

Waste Form/Contaminants:

Soil; Gravel/PCB Spill.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ characterization and monitoring

TECHNOLOGY: Immunoassay PCB

STATUS: Demonstration, testing and evaluation needed

Support/Application Evaluation: Mechanical Host Disturbance

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Risk Assessment
Technical Assessment
Regulatory

Applicable Contaminant Evaluation: Organic (Oil, PCBs, VOCs,
TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:**IMPLEMENTATION NEEDS:**

The technology is ready to apply and should be used for routine analyses at the K-25 Site.

COMMENTS:

Amount of Waste Produced--Small amount of reagents

Overall Cost--\$80 per test (\$35 per kt; 20-30 tests per person per day)

Efficacy/Strengths--It was thoroughly evaluated in DOE site restoration to minimize false negatives with the commercially-available test kit. It is very sensitive (5 ppm).

EVALUATOR: R.B. Gammage

Phone (615) 574-6256

REFERENCES:

It was evaluated in DOE Analytical Field Screening Program. Contact Dr. Roger Jenkins at ACD-ORNL.

INEL PROBLEM SITES:

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.
OU 4-09, CFA-10.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Hazardous-organics.

Waste Form/Contaminants:

Soil: Gravel/PCB spill.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ characterization and monitoring

TECHNOLOGY: Gas Chromatograph (GID, IC, TC) /electron capture detector (ECD) for Analyzing PCBs in Soil/Dust

PCBs are extracted with solvent from soil using a simple, two-step procedure. The extract is then injected into a field gas chromatograph that separates the sample components and selectively detects halogenated species, including PCBs. Arachlors (PCB mixtures) are identified by their separation pattern and can be quantified using specific chromatographic peaks.

STATUS: Accepted

Support/Application Evaluation: Mechanical Host Disturbance

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Risk Assessment
Technical Assessment
Regulatory

Applicable Contaminant Evaluation: Organic (Oil, PCBs, VOCs, TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:

Minimal depending on the application.

IMPLEMENTATION NEEDS:

GC/ECD devices (approximately \$15K each). Instrument costs, \$7 - 30K each; Development costs, \$25 - 100K.

COMMENTS:

Amount of Waste Produced--Small amounts of methanol/hexane extractant

Overall Cost--A few dollars per analysis; the gas chromatograph costs \$15K

Efficacy/Strengths--It was developed and verified by the EPA. One technician can conduct tens of analyses per day. One manager at a Superfund site estimated on-site data during tens of analyses per day. One manager at a Superfund site estimated on-site data during removal saved \$500K (360 analyses in 8 days). The method is accurate to below 10ppb.

EVALUATOR: R.B. Gammage

Phone (615) 574-6256

REFERENCES:

Dr. Tom Spittler, EPA Region I Director, is the contact. Method description is available. User courses are given regularly.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TSF-06, TAN V-1, TAN V-2, TAN V-3, TSF-PM2A; OU 3-07, CPP-26, CPP-28, CPP-79; OU 3-08, CPP-27; OU 3-12, CPP-81, CPP-82.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-07; OU 3-09, CPP-01, CPP-04, CPP-05, CPP-06, CPP-09; OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-35, CPP-36; OU 3-08, CPP-29; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible, corrosive, metals; Radioactive, mixed radioactive, hazardous-organic, transuranic, Rocky Flats fire waste, Pu, fuel end boxes.

Waste Form/Contaminants:

Soil; Concrete; Sludge; Debris-paper, rags, sweepings, vehicles, diatomaceous earth, wood, metal, glass; Floor; Asphalt/¹³⁷Cs, ⁶⁰Co, ⁹⁰Sr, ¹⁰⁶Ru, ¹⁵⁴Eu, low levels of Pu, mercuric nitrate, nitric acid, Hg, ¹³⁷Cs and ¹³⁴Cs at 2R/hr., TCE, toluene, carbon tetrachloride, Pu, ¹³⁷Cs and ¹³⁴Cs at 200mR/hr.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ passive monitors for surface contamination by weak beta radionuclides.

TECHNOLOGY: In Situ Passive Monitors For Surface Contamination By Weak Beta Radionuclides

The exoelectron technique is the weakly penetrating radiation analog to thermoluminescence, which is the standard for passive, solid-state dosimetry for strongly penetrating radiations. The exposed exoelectron dosimeter is heated to liberate low-energy electrons from a thin surface layer. The thin exoelectronic layer is especially sensitive to low-energy, beta radiations such as those from ³H, ¹⁴C or ⁹⁹Tc. The exoelectrons expelled during heating are counted in a Geiger or proportional counter, and the reading converted to an equivalent dpm/unit area.

STATUS: Demonstration, testing and evaluation needed

Support/Application Evaluation: Mechanical Host Disturbance
Thermal Host Disturbance
High-Energy Host Disturbance
Obstructed/Limited Access to Host

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Risk Assessment
Technical Assessment
Regulatory

Applicable Contaminant Evaluation: Radioactive (B)

SCIENCE AND TECHNOLOGY NEEDS:

A thorough evaluation of this technology for use in mixed surface contamination areas is needed. Testing and evaluation of ceramic exoelectron materials to select most suitable type for site-specific applications.

IMPLEMENTATION NEEDS:

A commercial exoelectron reader is available. Different types of ceramic exoelectron materials should be tested to select the most suitable type.

COMMENTS:

Amount of Waste Produced--None

Overall Cost--About \$300K for materials development work. <\$25 per detector which can be deployed in large numbers.

Efficacy/Strengths--It has a reusable, TLD-like chip with a signal-to-noise ratio of 10 after 100 min. exposure for a mCi/cm² of tritium. Small size detectors are available for monitoring difficult-to-access locations. It is highly sensitive to weak beta emitters such as tritium, C-14, and Tc-99. Other survey meters have low sensitivity and cannot access tight spaces.

EVALUATOR: R.B. Gammage Phone (615) 574-6256

REFERENCES:

"Measuring Tritium With Exoelectron Dosimeters," R.B. Gammage, *Nucl. Inst. Methods* 127, pp. 279-284 (1975).

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INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.

OU 1-05, TSF-06, TAN V-1, TAN V-2, TAN V-3, TSF PM2A; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-79; OU 3-08, CPP-27; OU 3-09, CPP-69; OU 3-12, CPP-81, CPP-82.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-07; OU 3-09, CPP-01, CPP-01, CPP-04, CPP-05, CPP-06, CPP-09; OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29, CPP-35, CPP-36; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

Also located in General Section, Characterization, Volume 2. Common to all characterization activities.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible, liquid; Mixed low-level radioactive-noncompactible, corrosive, metals; Radioactive, mixed radioactive, hazardous-organics, transuranic, Rocky Flats fire waste, Pu, fuel end boxes.

Waste Form/Contaminants:

Debris-paper, rags, sweepings, vehicles, diatomaceous earth, wood; glass, concrete, metals; Laboratory waste-liquid; Concrete; Soil; Liquid; Sludge; Floor; Asphalt/¹³⁷Cs, ¹³⁴Cs, ¹⁴⁴Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹⁵⁴Eu, ¹¹⁰Ag, ¹⁰⁶Ru, silver, mercury, plus radioisotopes, low levels of Pu, mercuric nitrate, nitric acid, Hg, TCE, toluene, carbon tetrachloride, Pu, ¹³⁷Cs and ¹³⁴Cs at 200mR/hr.

SUBELEMENTS: Characterization**ALTERNATIVES:** Sampling; In situ characterization and monitoring**TECHNOLOGY:** NaI-Ge Gamma Spectroscopy

The NaI detector is used to quantify ²³⁵U and ²³⁸U in items that allow the gamma to penetrate. The Ge detector is used to complete the attenuation correction factors for the NaI data.

STATUS: Accepted**Support/Application Evaluation:** All

Temporal Areas of Evaluation: Pretreatment
 During Treatment
 Posttreatment

Deployment Evaluation: Manual Applications
 Robotic Applications

Driver Evaluation: Technical Assessment
 Risk Assessment
 Regulatory

Applicable Contaminant Evaluation: Radioactive (abg)

SCIENCE AND TECHNOLOGY NEEDS:

Correction factor methodology needs to be published.

IMPLEMENTATION NEEDS:

None

COMMENTS:

Amount of Waste Produced--

Overall Cost--\$40K per combination NaI and Ge detectors

Efficacy/Strengths--The technology is useful for ^{235}U and ^{238}U detection. The system can measure radioactivity below the surface. It is relatively inexpensive. A high-resolution Ge detector may be needed to determine correction factors for attenuation. Sensitivity = $10\text{g } ^{235}\text{U}$; $500\text{g } ^{238}\text{U}$.

EVALUATOR: R.C. Hagenhauer Phone (615) 574-8835

REFERENCES: K/ITP-237, *Nondestructive Assay Measurements of Gaseous Diffusion Process Equipment*.

INEL PROBLEM SITES:

Located in General Section, Characterization, Volume 2. Common to all characterization activities.

PROBLEM AREAS/CONTAMINANTS: N/A

SUBELEMENTS: Characterization

ALTERNATIVES: Sampling; laboratory characterization and analysis

TECHNOLOGY: Neutron Activation (^{252}Cf Shuffler Or Differential Dic-Away System)

Neutrons generated by the instrument interact with ^{235}U to cause fission. The fission neutrons are then detected to quantify the ^{235}U .

STATUS: Accepted

Support/Application Evaluation: All

Temporal Areas of Evaluation: Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Regulatory

Applicable Contaminant Evaluation: Inorganic (U)

SCIENCE AND TECHNOLOGY NEEDS:

Development is needed for containers that are larger than 55-gallon drums. Separate calibration standards are needed for each matrix.

IMPLEMENTATION NEEDS:

Cost: Equipment \$0.5 - 1.5M.

COMMENTS:

Efficacy/Strengths--It is generally used for low-level determinations of uranium in almost anything. It is specific for ^{235}U and useful in most any matrix. The equipment is expensive (\$0.5--1.5 million). This is the most sensitive unit on the market for the nondestructive assay of uranium. Sensitivity is ~10 mg ^{235}U /55-gallon drum.

EVALUATOR: R.C. Hagenhauer Phone (615) 574-8835

REFERENCES: *Capability and Limitation Study of the DOT Passive-Active Neutron Waste Assay Instrument*, LA-12237

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TSF-06, TAN V-1, TAN V-2, TAN V-3, TSF-PM2A; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-31, CPP-79; OU 3-08, CPP-27, OU 3-12, CPP-81, CPP-82.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-07; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06, CPP-09; OU 5-12, PBF-08, PBF-10; OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29, CPP-35, CPP-36; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

Also located in General Section, Characterization, Volume 2. Common to all characterization activities.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible, corrosive, metals; Radioactive, mixed radioactive, hazardous-organics, transuranic, Rocky Flats fire waste, Pu, and fuel end boxes.

Waste Form/Contaminants:

Debris-concrete, rags, paper, sweepings, vehicles, diatomaceous earth, wood, glass, metals; Laboratory waste-liquid; Concrete; Sludge; Floor; Asphalt/¹³⁷Cs, ¹⁴⁴Cs, ¹³⁴Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ¹⁵⁴Eu, ¹¹⁰Ag, ¹⁰⁶Ru, silver, mercury, plus radioisotopes, low levels of Pu, mercuric nitrate, nitric acid, Hg, plutonium at low levels, kerosene, tri-butyle phosphates, ¹³⁷Cs and ¹³⁴Cs at 2R/hr., chromium, TCE, toluene, carbon tetrachloride, Pu, ¹³⁷Cs, and ¹³⁴Cs at 200mR/hr.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ characterization and monitoring

TECHNOLOGY: Proportional Counting for Alpha, Beta Activity

Alpha and beta radiation emitted from the surface contamination is detected and counted.

STATUS: Accepted

Support/Application Evaluation: All

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications
 Robotic Applications

Driver Evaluation: Regulatory

Applicable Contaminant Evaluation: Radioactive (abg)

SCIENCE AND TECHNOLOGY NEEDS:

This is a well-established technology. Some minor development may be needed to distinguish Tc activity from uranium. Probes for measuring vertical or overhead items are needed.

IMPLEMENTATION NEEDS:

Low implementation costs.

COMMENTS:

Efficacy/Strengths--It has sensitivity to 100 dpm/cm². Relatively inexpensive probes are available for wide areas or measurements, or it can be made small to measure inside pipes. It may be able to distinguish Tc activity from uranium.

EVALUATOR: R.C. Hagenhauer Phone (615) 574-8835

REFERENCES: Martin Marietta Energy Systems Staff Members, ORNL, Oak Ridge, TN, 37381

INEL PROBLEM SITES:

Located in General Section, Characterization, Volume 2. Common to all characterization activities.

PROBLEM AREAS/CONTAMINANTS: N/A

SUBELEMENTS: Characterization

ALTERNATIVES: Sampling

TECHNOLOGY: Waste Curie Monitor (Bag or Barrel Counter for Low-Level Radioactivity)

Gamma rays are emitted by the contaminated samples that are detected by the large plastic scintillators surrounding the 55-gallon drums.

STATUS: Accepted

Support/Application Evaluation: All

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Regulatory
Risk Assessment

Applicable Contaminant Evaluation: Radioactive (g)

SCIENCE AND TECHNOLOGY NEEDS:

Development may be necessary for containers larger than 55-gallon drums.

IMPLEMENTATION NEEDS:

Normal

COMMENTS:

Amount of Waste Produced--None

Efficacy/Strengths--It is good for measuring scrap lumber for low levels of activity (below 32 PCi/g). It must be used in conjunction with a high-resolution gamma spectroscopy systems to determine atomic abundance. It is presently used for low-level measurements of combustible waste. Sensitivity for ^{235}U =10 mg for ^{238}U =200 mg.

EVALUATOR: R.C. Hagenhauer Phone (615) 574-8835

REFERENCES: Martin Marietta Energy Systems Staff Members, ORNL, Oak Ridge, TN, 37381

INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38, TSF-03.

Unexploded naval ordnance.

OU 1-10, Ordinance.

Landfills.

OU 4-12, CFA-02, CFA-03.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Hazardous-organics, metals, recyclables; Low-level radioactive-noncompactible; Mixed low-level radioactive-metals; Municipal-sanitary.

Waste Form/Contaminants

Debris-glass, paper, plastic; Soil; Concrete; Wood; Lead shot, bricks, batteries; Solid; Sludge/Any metal or laboratory chemical; Heavy hydrocarbons, Pb, lead, mercury, chromium, trivalent chromium, metal, plutonium at low levels, kerosene, tri-butyle phosphates, ⁶⁰Co, ¹³⁷Cs, paint thinner, beryllium, trichloroethane.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ characterization and monitoring

TECHNOLOGY: Laser-ablation; Inductively Coupled Plasma; Atomic Emission Spectroscopy (LA-ICP-AES)

LA-ICP-AES is used for direct analysis of solid samples for elemental constituents. A high energy laser volatilizes a portion of the sample and the generated aerosol is swept into the plasma of the ICP-AES. The high energy plasma dissociates and excites the species in the volatilized sample. Elements are detected by measuring light emitted by the excited species at characteristic wavelengths and correlating the emission intensities to concentrations.

STATUS: Demonstration, testing and evaluation needed

Support/Application Evaluation: High-Energy Host Disturbance

Temporal Areas of Evaluation: Pretreatment
Posttreatment

Deployment Evaluation: Robotic applications

Driver Evaluation:

Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Inorganic (U, Tc, Cr, CrO₄,
Hg, Pb,...)

SCIENCE AND TECHNOLOGY NEEDS:

We need to improve the robotic process for site-specific conditions (e.g., floor, wall, ceiling).

IMPLEMENTATION NEEDS:

Normal

COMMENTS:

Efficacy/Strengths--It will be accepted by end of this year after the Fernald demonstration. It allows multiple elemental analyses.

EVALUATOR: S.Y. Lee Phone (615) 574-6316

REFERENCES: Contact Marvin Anderson, Ames Laboratory, Ames, IA 50010-6739, at (515) 294-4580.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.

OU 1-05, TSF-06, TAN V-1, TAN V-2, TAN V-3, TSF-PM2A; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-79; OU 3-08, CPP-27; OU 3-09, CPP-69, OU 3-12, CPP-81, CPP-82.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-07; OU 3-09, CPP-01, CPP-01, CPP-04, CPP-05, CPP-06, CPP-09; OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29, CPP-35, CPP-36; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

Also located in General Section, Characterization, Volume 2. Common to all characterization activities.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible, liquid; Mixed low-level radioactive-noncompactible, corrosive, metals; Radioactive, mixed radioactive, hazardous-organics, transuranic, Rocky Flats fire waste, Pu, fuel end boxes.

Waste Form/Contaminants:

Debris-paper, rags, sweepings, vehicles, diatomaceous earth, wood; glass, concrete, metals; Laboratory waste-liquid; Concrete; Soil; Liquid; Sludge; Floor; Asphalt/¹³⁷Cs, ¹³⁴Cs, ¹⁴⁴Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹⁵⁴Eu, ¹¹⁰Ag, ¹⁰⁶Ru, silver, mercury, plus radioisotopes, low levels of Pu, mercuric nitrate, nitric acid, Hg, TCE, toluene, carbon tetrachloride, Pu, ¹³⁷Cs and ¹³⁴Cs at 200mR/hr.

SUBELEMENTS: Characterization**ALTERNATIVES:** In situ characterization and monitoring**TECHNOLOGY:** Portable Gamma-Ray Spectrometry

Characterization and monitoring technologies are available but need to be put together for in situ implementation. Application of sensor technology for in situ characterization and monitoring requires robotic technology and remote control technology.

Portable Gamma Ray Spectrometry is a technology used for detection of gamma emitters such as manganese-54, cobalt-60, zinc-65, ruthenium-105, silver-108m, silver-110m, antimony-125, cesium-134, cesium-137, cerium-144, europium-152, -154, -155, uranium-235 and americium-241. Each isotope has a specific set of gamma energies used for identification of that isotope. Samples are placed in a known geometry and counted using a germanium detector. The results are

identified by the gamma energies and quantified based upon known efficiencies for the particular energy region and the geometry used.

STATUS: Accepted

Support/Application Evaluation: Mechanical Host Disturbance

Temporal Areas of Evaluation: Pretreatment
Posttreatment

Deployment Evaluation: Robotic Applications

Driver Evaluation: Risk Assessment
Technical Assessment

Applicable Contaminant Evaluation: Radioactive (g)

SCIENCE AND TECHNOLOGY NEEDS:

We need robotic technology for remote control applications.

IMPLEMENTATION NEEDS:

Technologies are available but need to be put together for implementation.

COMMENTS:

Efficacy/Strengths--It is only for uranium and other actinide isotopes.

EVALUATOR: S.Y. Lee Phone (615) 574-6316

REFERENCES: N.H. Cutshall, ORNL

INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 1-03, TSF-03.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 3-08, CPP-15.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.
OU 1-03, TSF-03; OU 1-06, LOFT-01; OU 4-09, CFA-26, CFA-42.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Hazardous-organics; Low-level radioactive-noncompactible.

Waste Form/Contaminants:

Soil; Concrete/Mercury, plutonium at low levels, kerosene, tri-butyle phosphates, diesel fuel.

SUBELEMENTS: Characterization

ALTERNATIVES: Laboratory characterization and analysis

TECHNOLOGY: On-Line Supercritical Fluid Extraction, Multidetector Gas Chromatography (SFE-GC)

This technology extracts specific fluids by using supercritical pressures and temperatures in real time. The extracted fluids are then analyzed by nultidetector gas chromatography.

STATUS: Research and development needed

Support/Application Evaluation: N/A

Temporal Areas of Evaluation: Pretreatment
During Treatment
Posttreatment

Deployment Evaluation: Manual Applications

Driver Evaluation: Regulatory

Applicable Contaminant Evaluation: Organic (Oil, PCBs, VOCs,
TCE,...)

SCIENCE AND TECHNOLOGY NEEDS:

The technology requires optimization for the most efficient analysis of both total petroleum hydrocarbons and PCBs in a single operation.

IMPLEMENTATION NEEDS:

Normal

COMMENTS:

Amount of Waste Produced--None

Overall Cost--It could be 25% or even less than that of separate conventional analyses.

Efficacy/Strengths--Organic, solvent-contaminated wastes are not generated, as opposed to conventional organic analytical methods. There is also much faster sample turnaround than with conventional methods. There is also much faster sample turnaround than with conventional methods. One commercial instrument already is available for the rapid determination of total petroleum hydrocarbons in soil by on-line SFE-GC. The SFE of PCBs also has been demonstrated. It appears highly likely that the two methods can be combined to allow the rapid and simultaneous analysis of both contaminants in soil and other solids.

EVALUATOR: W. H. Griest

REFERENCES: Available upon request.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 2-05, TRA-15.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Mixed low-level radioactive.

Waste Form/Contaminants:

Laboratory Waste-liquid/Silver, mercury, plus radioisotopes, ⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ physical

TECHNOLOGY: Fiber optic camera systems

This technology uses fiber optics for image transmission. The advantages are small size, flexibility, and maneuverability.

STATUS: Accepted

Commercially available.

SCIENCE AND TECHNOLOGY NEEDS:

System resolution and portability improvement pursued commercially. Development of hardened camera for hazardous environments.

IMPLEMENTATION NEEDS:

Available system costs, \$40K.

COMMENTS:

None.

EVALUATOR: R. H. Meservey

Phone (208) 526-1034

FAX (208) 526-1393

REFERENCES:

None provided. For additional information, contact the above evaluator.

INEL PROBLEM SITES:

Radioactive underground tanks, aboveground storage tanks, and associated soils.

OU 1-05, TAN V-1, TAN V-2, TAN V-3, TSF-PM2A, TSF-06; OU 2-05, TRA-15; OU 3-07, CPP-28, CPP-31; OU 3-08, CPP-27; OU 3-12, CPP-81, CPP-82.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 2-09, TRA-07; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06; OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29, CPP-35; OU 3-09, CPP-03, CPP-08, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

Unexploded naval ordnance.

OU 10-03, Ordnance Areas.

Landfills.

OU 4-12, CFA-03.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible, corrosive, metals; Radioactive, mixed radioactive, hazardous-organic, transuranic, Rocky Flats fire waste, Pu, fuel end boxes; Hazardous-unexploded ordnance; Nonhazardous-metal; Municipal-sanitary.

Waste Form/Contaminants:

Debris-concrete, metals, rags, paper, sweepings, vehicles, diatomaceous earth, wood, glass; Soil; Concrete; Floor; Asphalt; Ordnance/¹³⁷Cs, ¹³⁴Cs, ¹⁴⁴Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ¹⁵⁴Eu, ¹¹⁰Ag, ¹⁰⁶Ru, mercuric nitrate, nitric acid, plutonium at low levels, kerosene, tri-butyle phosphates, chromium, TCE, toluene, carbon tetrachloride, Pu, ¹³⁷Cs and ¹³⁴Cs at 200mR/hr., TNT, RDX, composition B, lithium, tetryl, picric acid, smokeless powder, old black powder, ametol.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ physical

TECHNOLOGY: Ground penetrating radar

Extremely short electromagnetic pulse return interference by both metallic and nonmetallic objects.

STATUS: Accepted

Commercially available.

SCIENCE AND TECHNOLOGY NEEDS:

Improvements are needed in depth of penetration and signal-to-noise and signal processing, particularly antenna design. The technology could be developed to measure subsurface plumes.

IMPLEMENTATION NEEDS:

The system would cost approximately \$30K.

COMMENTS:

None.

EVALUATOR: J.E. Nyquist Phone (615) 574-4646

REFERENCES:

Workshop on Noninvasive Geophysical Site characterization, LA-12311-C.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.

OU 1-05, TAN V-1, TAN V-2, TAN V-3, TSF-PM2A, TSF-06; OU 2-05, TRA-15; OU 3-07, CPP-28; OU 3-08, CPP-27; OU 3-12, CPP-81, CPP-82.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 2-09, TRA-07; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06; OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29, CPP-35; OU 3-09, CPP-03, CPP-08, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

Unexploded naval ordnance.

OU 10-03, Ordnance Areas.

Landfills.

OU 4-12, CFA-03.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible, corrosive, metals; Radioactive, mixed radioactive, hazardous-organics, transuranic, Rocky Flats fire waste, Pu, and fuel end boxes; Hazardous-unexploded ordnance; Nonhazardous-metal; Municipal-sanitary.

Waste Form/Contaminants:

Debris-concrete, metals, paper, rags, sweepings, vehicles, diatomaceous earth, wood, glass; Concrete; Soil; Floor; Asphalt; Ordnance/¹³⁷Cs, ¹³⁴Cs, ¹⁴⁴Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹⁵⁴Eu, ¹⁰⁶Ru, ¹¹⁰Ag, mercuric nitrate, nitric acid, plutonium at low levels, kerosene, tri-butyle, phosphates, chromium, TCE, toluene, carbon tetrachloride, Pu, TNT, RDX, Composition B, lithium, tetryl, picric acid, smokeless powder, old black powder, ametol, ¹³⁷Cs and ¹³⁴Cs at 200mR/hr.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ physical

TECHNOLOGY: Electrical and Electromagnetic (EM) Methods

This includes measurements based on electrical conductivity and those which measure natural electrical potentials.

STATUS: Demonstration, testing and evaluation needed

SCIENCE AND TECHNOLOGY NEEDS:

Development of site-specific techniques, and data handling and imaging methods are needed. The Lawrence Livermore National Laboratory-developed borehole system could be adapted for use in Oak Ridge.

IMPLEMENTATION NEEDS:

Development cost is estimated to be \$200K; systems cost, \$100K. Commercial rental equipment is available.

COMMENTS:

None.

EVALUATOR: J.E. Nyquist Phone (615) 574-4646

REFERENCES:

1. Workshop on Noninvasive Geophysical Site Characterization, LA-12311-C.

INEL PROBLEM SITES:

Unexploded Naval Ordnance.

OU 10-03, Ordnance Areas.

Landfills.

OU 4-12, CFA-03.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Municipal-Sanitary; Hazardous-unexploded ordnance; Nonhazardous-metal.

Waste Form/Contaminants:

Debris; Soil; Ordnance/TNT, RDX, Composition B, lithium, tetryl, picric acid, smokeless powder, old black powder, ametol.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ physical

TECHNOLOGY: Seismic Methods (refraction, profiling, reflection)

Seismic methods measure elastic and acoustic subsurface parameters.

STATUS: Demonstration, testing and evaluation needed

Refraction and deep reflection have been used successful for years; however, shallow (<30m) reflection capability is relatively recent.

Efficacy: Useful for identifying and mapping geological features which control contaminant migration.

SCIENCE AND TECHNOLOGY NEEDS:

Developed shallow sources should be tested. Techniques should be adapted and used for both vertical and horizontal boreholes.

IMPLEMENTATION NEEDS:

Development cost is estimated at approximately \$200K; systems cost, \$50K. Commercial rental equipment is available.

COMMENTS:

None.

EVALUATOR: J.E. Nyquist

Phone (615) 574-4646

REFERENCES:

Workshop on Noninvasive Geophysical Site Characterization, LA-12311-C.

INEL PROBLEM SITES:

Unexploded naval ordnance.

OU 10-03, Ordnance Areas.

Landfills.

OU 4-12, CFA-03.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Hazardous-unexploded ordnance; Nonhazardous-metal; Municipal-sanitary.

Waste Form/Contaminants:

Soil; Ordnance; Debris/TNT, RDX, Composition B, lithium, tetryl, picric acid, smokless powder, old black powder, and ameto.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ physical

TECHNOLOGY: Microgravity Methods

This technology involves measuring variations in the earth's gravitational field caused by differences in the densities of objects such as rocks, natural structures, and artifacts.

STATUS: Demonstration, testing, and evaluation needed.

Efficacy: Gravity methods have been successfully used in the mining and petroleum industries. Increased sensitivity is needed for accurate, unambiguous interpretation. Microgravity has been used at the K-25 site.

SCIENCE AND TECHNOLOGY NEEDS:

Development of increased sensitivity for rapid, cost-effective subsurface detection and mapping is needed. Also, site-specific development is needed for detecting karst cavities and conduits.

IMPLEMENTATION NEEDS:

Development is expected to cost \$220K. Systems cost is expected to be \$60K. Commercial rental equipment is available.

COMMENTS:

None.

EVALUATOR: J.E. Nyquist

Phone (615) 574-4646

REFERENCES:

Workshop on Noninvasive Geophysical Site characterization, LA-12311-C.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TSF-06, TAN V-1, TAN V-2, TAN V-3, TSF-PM2A; OU 2-05, TRA-15; OU 3-07, CPP-28; OU 3-08, CPP-27.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU-3-08, CPP-15 OU 3-09, CPP-06; OU 5-12, PBF-10 OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-35; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22; OU 3-112, CPP-80

Unexploded naval ordnance.

OU 10-03, Ordnance Areas.

Landfills.

OU 4-12, CFA-03.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible; corrosives; metals; Radioactive, mixed radioactive, hazardous-organics, transuranic, Rocky Flats fire waste, Pu, and fuel end boxes; Hazardous-unexploded ordnance; Nonhazardous-metal; Municipal-sanitary.

Waste Form/Contaminants:

Debris-concrete, paper, rags, diatomaceous earth, wood, metal, glass; concrete; Floor; Asphalt; Ordnance/¹³⁷Cs, ¹⁴⁴Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ¹⁵⁴Eu, ¹¹⁰Ag, tetrachloride, Pu, ¹³⁷Cs, and ¹³⁴Cs at 200mR/hr., TNT, RDX, Composition B, lithium, tetryl, picric acid, smokeless powder, old black powder, and ametol.

SUBELEMENTS: Characterization

ALTERNATIVES: In situ physical

TECHNOLOGY: Magnetism

STATUS: Accepted

Useful for detecting buried ferrous metal objects. Aerial survey completed in Oak Ridge.

SCIENCE AND TECHNOLOGY NEEDS:

Development of methods to minimize interference is required.

IMPLEMENTATION NEEDS:

Implementation cost, \$200K; system cost \$100K. Commercial rental equipment is available.

COMMENTS:

None.

EVALUATOR: J.E. Nyquist Phone (615) 574-4646

REFERENCES:

Workshop on Noninvasive Geophysical Site characterization, LA-12311-C.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TAN V-1, TAN V-2, TAN V-3, TSF-PM2A, TSF-06; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-79; OU 3-08, CPP-27; OU 3-12, CPP-81, CPP-82.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-07; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06, CPP-09; OU 5-12, PBF-08; OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29, CPP-35, CPP-36; OU 3-09, CPP-03, CPP-08, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

Injection wells, groundwater, and associated plumes.

OU 3-07, CPP-83.

Also located in General Section, Characterization, Volume 2. Common to all characterization activities.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; Mixed low-level radioactive; Radioactive, mixed radioactive, hazardous-organics, transuranic, Rocky Flats fire waste, Pu, and fuel end boxes.

Waste Form/Contaminants:

Soil; Laboratory waste-liquid; Concrete; Sludge; Debris-paper, rags, sweepings, vehicles, diatomaceous earth, wood, metal, glass; Floor; Asphalt.

SUBELEMENTS: Characterization

ALTERNATIVES: Ex situ radiological (laboratory)

TECHNOLOGY: Liquid scintillation counting

STATUS: Accepted

Mature technology in current use.

SCIENCE AND TECHNOLOGY NEEDS:

None. "Off-the-shelf."

IMPLEMENTATION NEEDS:

In current use.

COMMENTS:

Generates organic waste contaminated with radioactivity. May be ideal for screening samples for gross alpha/beta content.

EVALUATOR: J. M. Keller

Phone (615) 574-7063

REFERENCES:

D. Horrocks, "Applications of Liquid Scintillation Counting", Academic Press, N.Y. (1974).

"Radiochemical Determination of Gross Alpha and Gross Beta Particle Activity in Water", Radiochemistry Procedures Manual, EPA 520/5-84-006, August 1984.

INEL PROBLEM SITES:

OU 3-08, CPP-15

PROBLEM AREAS/CONTAMINANTS:

Waste Type:

Low-level radioactive - noncompactible

Waste Form/Contaminants:

Rocks (basalt), leaves, soil, and vapors

SUBELEMENTS: Characterization

ALTERNATIVES: Ex-situ characterization

TECHNOLOGY: Secondary Ion Mass Spectrometry Analysis (SIMS Analysis)

STATUS: Accepted

This technology has been demonstrated to have nanogram detection sensitivities for tri-butyle phosphate adsorbed into basalt from both Hanford and INEL. Sub-monogram sensitivities are observed if it is adsorbed from the gas phase, giving excellent promise as a gas phase detector. Samples require no preparation other than to be less than 0.5 inches in thickness and have the contaminant on the surface, since this is a surface analysis. No waste is generated since the samples are analyzed without preparation.

SCIENCE AND TECHNOLOGY NEEDS:

This technology has advanced to the stage where field sampling and analyses are practical. Vapor phase monitors which can be lowered into a well may be needed to be developed. A field portable ion trap based SIMS is to be developed next year.

IMPLEMENTATION NEEDS:

This technology is available for laboratory use at the INEL, but, it will need approximately 2 to 3 years of continued development for field use.

COMMENTS:

Contact the evaluator for additional information on the development of the field portable ion trap based SIMS.

EVALUATOR: James E. Delmore

Phone (208) 526-2820

REFERENCES:

None provided. For more information, contact the above evaluator.

INEL PROBLEM SITES:

OU 10-03, Ordnance areas including NODA; RWMC areas.

PROBLEM AREAS/CONTAMINANTS:

SUBELEMENTS: Characterization

ALTERNATIVES:

TECHNOLOGY: Infrared Analysis of Wastes (FTIR-PAS)

STATUS: Demonstration, testing, and evaluation needed

FTIR-PAS is still developmental but has an excellent chance of becoming proven and demonstrated technology in the near future (within 1 year). FTIR-PAS extends the detection capability of FTIR to also analyze solids and sludges, and is uniquely capable of analyzing explosive molecules and ionic series in an inherently safe way with no special sample preparation. FTIR-PAS requires discreet sampling and analysis methods at present and instrumentation development is needed to provide automatic sampling and to improve the analysis capability.

FTIR is field proven and well accepted for monitoring Superfund Site work either singly or in combination with Gas Chromatography for gas phase and some liquid phase sampling.

SCIENCE AND TECHNOLOGY NEEDS:

FTIR-PAS: The methodology for rapidly and routinely producing quantitative analysis results from small surrogate waste samples with a minimum of sample handling is required. The results of this work then needs to be demonstrated on radioactive wastes and explosive-type wastes under actual field conditions.

IMPLEMENTATION NEEDS:

Implementation needs not currently defined.

COMMENTS:

None.

EVALUATOR: John Jolley Phone (208) 526-8036
 Steve Webster Phone (708) 252-2822.

REFERENCES:

Equipment vendors: MDA Scientific; MIDAC; NICOLET; and BOMEN.

2. RETRIEVAL

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.

OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-31, CPP-79; OU 3-09, CPP-69; OU 3-12, CPP-81, CPP-82; OU 3-13, CPP-39.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-04, LOFT-02; OU 2-07, TRA-36, TRA-39; OU 4-05, CFA-04.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-13; OU 3-08, CPP-15; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06, CPP-09; OU 3-13, CPP-48; OU 5-12, PBF-08, PBF-10; OU 7-13, RWMC-04.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 4-09, CFA-10; 7-08, RI/FS.

Radioactive spills areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29, CPP-36; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

PROBLEM AREA/CONSTITUENTS:**Waste Form:**

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible, metals; Hazardous-organics, metals; Municipal sanitary-liquid; Indeterminate; Radioactive, mixed radioactive, hazardous-organics, transuranic, Rocky Flats fire waste, Pu, fuel end boxes.

Waste Type/Contaminants:

Concrete; Soil; Debris-glass, paper, rags, sweepings, vehicles, diatomaceous earth, wood, metal, glass, plastic, trash; Sediment; Laboratory waste-liquid; Sludge; Gravel; Petroleum/⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag, Hg, low levels of Pu, mercuric nitrate, nitric acid, any metal or laboratory chemical, heavy hydrocarbons, chromium, mercury, TCE, TCA, xylene in parts per billion, (1000pCi/g), ²³⁹Pu, ²⁴⁰Pu (1pCi/g), (5pCi/g), lead, toluene, carbon tetrachloride, Pu, diesel fuel, paint thinner, PCB spill, diesel fuel, beryllium, and trichloroethane.

SUBELEMENTS: Retrieval

ALTERNATIVES: Containment

TECHNOLOGY: Containment Structures

Containment Structures are temporary structures which provide negative or positive pressure capabilities for the containment of emissions during environmental restoration activities.

STATUS: Accepted

Currently accepted and proven technology used by the construction and demolition industries for selective size reduction and other demolition operations. Application is directly related to the remediation of problems similar to the identified site specific work tasks.

These temporary containment structures are fairly expensive (e.g. for a typical 130'x 200' structure ==> \$) at approximately \$/sf. However, once procured for use at the INEL, the structure would have multiple uses at the various environmental restoration sites.

SCIENCE AND TECHNOLOGY NEEDS:

No new scientific investigation and/or technological development is necessary to fully implement commercially available equipment, sized to meet the identified site specific work tasks.

There was one exhibitor at Con Expo '93 displaying information on temporary structures which could be utilized for construction isolation/containment or warehousing applications. Sprung Structures Inc. (1001-10 Avenue SW, Calgary, Alberta, Canada T2R 0B7, Phone (403) 245-3371 or (800) 528-9899). Sprung Structures Inc., is also advertising their structures as having negative and positive pressure capabilities and, therefore applicable to environmental restoration emissions containment. These structures have no, or limited foundation requirements. They have offices in Allentown, PA; San Francisco, CA; Los Angeles, CA; Fontana, CA; Atlanta, GA; Houston, TX; Indianapolis, IN, and Calgary, AB.

Another manufacturer of similar rigid structures is Clamshell Buildings, Inc. (1990 Knoll Drive, Ventura, CA 93003, Phone (805) 650-1700). These structures have modular capabilities and come in freespan widths from 28' to 220', and have no, or limited foundation requirements.

There are other manufacturers of temporary structures and further research should be done to develop this list.

IMPLEMENTATION NEEDS:

Most of these temporary containment structures do not have any (or have very limited) foundation requirements. There would need to be electrical and HVAC utility systems to support these structures with heat, light, HVAC, and positive or negative pressure as required. If the INEL were to procure one or more of these structures, there would be some additional personnel training required for the INEL personnel doing the mobilization and demobilization of these structures.

COMMENTS:

For limited applications of these structures at the INEL, it would be advantageous to subcontract the mobilization and demobilization of the structure and rent the structure from the subcontractor. This would eliminate the additional training but, would not allow the INEL to have its own independent containment structure system (which may be of value in the near future depending upon the EPA decisions on necessary containment).

EVALUATOR: Donald J. Kenoyer Phone (208) 526-9837
FAX (208) 526-2714

REFERENCES:

None provided. For more information, contact the above evaluator.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.

OU 1-05, TSF-06; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-31; CPP-79; OU 3-12, CPP-81, CPP-82; OU 3-13, CPP-39.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38, TSF-03, WRRTF-01; OU 1-04, LOFT-02; OU 2-07, TRA-36, TRA-39; OU 4-05, CFA-04, CFA-17; OU 4-06, CFA-06, CFA-43.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 3-08, CPP-15; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06, CPP-09; OU 3-13, CPP-48; OU 5-12, PBF-10; OU 7-13, RWMC-04.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 1-06, LOFT-01; OU 3-11, CPP-45; OU 4-06, CFA-44; OU 4-09, CFA-10, CFA-26, CFA-42; OU 7-08, RI/FS.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29, CPP-35; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-17, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

Landfills.

OU 4-12, CFA-02, CFA-03.

PROBLEM AREA/CONSTITUENTS:**Waste Types:**

Low level radioactive-noncompactible, combustible; Mixed low level radioactive-noncompactible; Hazardous-organics, metals, recyclable; Municipal sanitary-trash, liquid; Mixed low level radioactive-metals; Radioactive, mixed radioactive, hazardous-organics, transuranic Rocky Flats fire waste, Pu, fuel end boxes.

Waste Form/Contaminants:

Debris-concrete, metals, glass, plastic, paper, sweepings, rags, vehicles, diatomaceous earth, wood; Concrete; Soils; Sludge; Lead chunks; Laboratory waste-liquid; Sediment; Gravel, Solid/¹³⁷Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag, low levels of Pu, mercuric nitrate, nitric acid, any metal or laboratory chemical, heavy hydrocarbons, Pb, chromium, mercury, fuel oil, lead, lead oxide, Hg, TCE, TCA, xylene in parts per billion, ⁶⁰Co, (1000pCi/g), ²³⁹Pu, ²⁴⁰Pu, (1pCi/g), diesel fuel, mercury, lead, paint thinner, petroleum, chromium, beryllium, trichloroethane.

SUBELEMENTS: Retrieval**ALTERNATIVES: Manual Excavation**

TECHNOLOGY: Manually Operated Excavator

STATUS: Accepted

Currently accepted and proven technology used by the construction and demolition industries for selective excavation, trenching, larger excavation sites, and demolition operations. Application is directly related to the remediation of problems similar to the identified site specific work tasks.

The term "excavator" may generate different images for each individual. To clarify this matter, the following terminologies will be explained for use in the Technology Logic Diagram (TLD) "Retrieval" section. As defined by Caterpillar, the major excavation equipment are:

- Backhoe Loaders Typical wheel chassis backhoe with front loader.
- Excavators Track-type backhoes, wheel-type backhoes, and mass excavators, which include backhoes and front shovels.
- Motor Graders Typical steel chassis motor grader.
- Scrappers Standard wheel tractor scrapers, elevating scrapers, tandem powered scrapers, and push-pull scrapers.
- Track Loaders Typical track chassis front loader.
- Track-Type Tractors Standard dozers, low ground pressure (LGP) dozers, and waste disposal dozers.
- Wheel Loaders Typical wheel chassis front loader.

For purposes of discussion in the TLD, the term "excavators" will refer to the front loaders (track and wheel types) and front shovels, while the term "backhoe" will refer to the track backhoe excavator and the backhoe loader types.

There are several types of manual excavators which are commercially available and technically proven. These would include the four-wheel drive, rubber tired and tracked "Front End Pay Loaders" and "Front End Shovels." The more common type of excavator seen on construction sites are the four-wheel drive, rubber tired, articulating "Front End Pay Loaders" for application to typical loading operations.

All of the manual excavators are operated through hydraulic pressure systems. The next generation of excavators operational cab is better designed for the operator (Ergonomics; seat comfort, control positions, viewing angles, etc.) and allows longer operation times with less operator fatigue. The next generation of loaders and shovels have more operator/computer

interface in which the operator instructs the computer to what type of operational mode to work in and the computer adjusts engine speeds for optimum utilization of excavator and fuel economy.

Serviceability is another item which received lots of attention (ease of access for field maintenance or repair work, standard maintenance or repair work, standard maintenance work reduced, etc.).

SCIENCE AND TECHNOLOGY NEEDS:

No new scientific investigation and/or technological development is necessary to fully implement commercially available equipment, sized to meet the identified site specific work tasks.

Each of these types of manual excavators have a wide range of equipment sizes to meet the desired performance characteristics required for the particular work task and site physical conditions. An example of this would be the available sizes of manual excavators--front end pay loader type. These range from the smaller 17,000-pound class, to the medium 48,000-pound class, to the super large 390,000-pound class, to the medium 48,000-pound class, to the super large 390,000-pound type (these typically have bucket sizes ranging from 1.6 cy to 40 cy and can exert a digging breakout force ranging from 20,000 lbs. to 315,000 lbs.). The available sizes of manual excavators--front end shovel types are fairly limited (Caterpillar only has two models). These models are of the larger size, 145,000-pound class (these typically have bucket sizes ranging from 2.5 cy to 7 cy).

The manual excavators also have a limited range of subsystem equipment sizes to meet the desired performance characteristics required. One of the major subsystems would include the track types and widths to be utilized with the chassis (e.g., shoe arrangement of the track one, two, or three for traction in varying soil conditions, steel or rubber inserts for use off-road or on-road applications, wider tracks for softer soil conditions, etc.).

As mentioned previously, there are several other major subsystems which must be determined and are specific to the type of equipment, e.g., "Front End Loaders" vs. "Front End Shovels." The following are some examples:

Front End Loaders:

Chassis Subsystems: Fixed body or articulating body. (Note: The articulating body provides more maneuverability due to shorter turning radius.)

Drive Subsystems: Tracked or 4-wheel drive, rubber tired. (Note: The 4-wheel drive, rubber tired subsystem is required for the articulating body type.)

Front End Shovel:

Second Arm Subsystems: Second arm lengths can be varied for different applications, e.g., short, medium, and long, second arms are available for heavy work applications, overall typical operations, and extended reach light work applications respectively.

One of the major subsystems which recently has had the largest growth in available types of equipment has been the work attachments. These would include the following types of attachments:

- Buckets Widths, sizes, and types (smooth faced, toothed faced, v-shaped, clam shell, etc.). Used for various excavation operations.
- Blades Widths, sizes, and types (smooth faced, tooth face, v-shaped, fixed or variable, straight or curved, etc.). Note: This attachment allows the loader to become a dozer and, therefore, provides more variability to the single piece of equipment.
- Hydraulic Rams Hydraulic jackhammers used to break up concrete structures, typically pavement applications. Note: This attachment is not typically applied to front end loaders or front end shovels but could be utilized as such.
- Shears Hydraulic shears used to downsize larger steel structures vs. manual labor utilizing cutting torches. Note: This attachment is not typically applied to front end loaders or front end shovels but could be utilized as such.
- Pulverizers Hydraulic concrete crushers used to pulverize or downsize large concrete structures while cutting and sorting out reinforcing steel. Note: This attachment is not typically applied to front end loaders or front end shovels but could be utilized as such.
- Specialized Barrel handling, forks, rippers, grapplers, augers, sweepers, snow blowers, cold planers, trenchers, hitched backhoe attachments, etc.
- Tires Widths, sizes, and types and associated accessories, i.e., such as chains for traction, chain mesh for protection, etc.

The more common type of attachments utilized with the manual excavators are the buckets and specialized attachments such as forks, grapplers, sweepers, etc. These manual excavators are not typically utilized for running attachments such as the compactors, hydraulic rams, shears, and pulverizers due their limited range of motion vs. the larger range of motion of a backhoe type of excavation equipment.

There are several manufacturers who make specific/specialized "loader attachments." Some of these manufacturers encountered at the Con Expo 1993 are listed below:

Du-Al Manufacturing Co., 1000 W. Cherokee Street, Sioux Falls, SD 57117-5041. Phone: (605) 336-3860.

Kenco Engineering, P.O. Box 1467, Roseville, CA 95678.
Phone: (916) 782-8494.

Kubota Tractor Corp., 550 W. Artesia Boulevard, Compton, CA 90220. Phone: (310) 537-2531.

Pemberton Inc., P.O. Box 520899, Longwood, FL 32752-0899.
Phone: (407) 831-6688.

Power Equipment Corp., 1110 Pennington Avenue, Thief River Falls, MN 56701. Phone: (218) 681-7130.

Recycling Attachments Intl., 31200 Solon Road, #4, Solon, OH 44139. Phone: (216) 349-1446. (Rotar Screen)

R.H. & M. Machine Co., Route #5, Box 542, Morgantown, WV 26505. Phone: (304) 296-7000.

Technology Enterprises Inc., P.O. Box 1309, Montrose, CO 81402-1309. Phone: (303) 249-1515.

Most major front end pay loader manufacturers also manufacture attachments for their particular equipment types. Some examples of these are listed below:

Dresser Marketing Division, 200 Tri-State International,
Lincolnshire, IL 60069. Phone: 1-800-635-7500 for local
Dresser attachment distributor.

There are many manufacturers of front end loaders or front end shovel-types of excavators within the United States, including foreign Americanized companies. The "Buy American" philosophy should not bias the engineering decisions on the best equipment available.

IMPLEMENTATION NEEDS:

None required.

COMMENTS:

The ER&WM D&D Projects Unit currently has a medium-sized 4-wheel drive, rubber tired, articulated, front-end loader with bucket. The following are the major equipment specifications for reference (more detailed specifications can be obtained upon request):

Michigan Model L120	
Operating Weight:	35,119 pounds
Operating Load	12,710 pounds

Engine: 4 cylinder, turbocharged,
diesel, 190 hp@000rpm
Chassis: 4-wheel drive, articulated,
rubber tired wheel loader
Bucket: 3.5 cy (yd3)

The ER&WM D&D Projects Unit currently has straight fork and grapple fork attachments for this loader and are utilized for moving of pallets, boxes, etc., as required by the job site conditions. Future attachment procurements would include the dozer blade attachment mentioned previously and the asphalt cutter attachment (used for neat-line cutting of asphalt).

EVALUATOR: Donald J. Kenoyer Phone (208) 526-9837
FAX (208) 526-2714

REFERENCES:

The following is a listing of the major manufacturers of front end loaders and front end shovels and does not attempt to be a complete listing. (Note: Some equipment manufacturers do not make both tracked and steeled front end loaders and/or front end shovels):

EXCAVATION EQUIPMENT MANUFACTURER

Caterpillar, Inc.
P.O. Box 10097
Peoria, IL 61612-8818
Phone: (309) 675-1000
(Tracked & wheeled front end
loaders and front end
shovels.)

Clark

(Wheeled front end loaders ONLY.)

Dresser Industries
P.O. Box 718
Dallas, TX 75221
Phone: (214) 740-6000
(Tracked & wheeled front end
loaders ONLY.)

LOCAL DISTRIBUTOR

Western States Equipment
2405 Garrett Way
Pocatello, ID 83401
Phone: (800) 832-2287

Arnold Machinery Co.
3330 N. Yellowstone Hwy.
Idaho Falls, ID 83401
Phone: (208) 523-0822

John Deere & Co.
John Deere Road
Moline, IL 61265
Phone: (309) 765-8000
(Tracked & wheeled front end
loaders ONLY.)

J.I. Case Co.
900 Alderson Street
Schofield, WI 54476
Phone: (715) 359-6511
(Tracked & wheeled front end
loaders ONLY.)

Komatsu Equipment

(Wheeled front end loaders
ONLY.)

Kubota Tractor Corp.
550 W. Artesia Boulevard
Compton, CA 90220
(Wheeled front end loaders
ONLY/Smaller types ONLY.)

Liebherr America Inc.
4100 Chestnut Avenue
Newport News, VA 23605
Phone: (804) 245-5252
Tracked & wheeled front end
loaders ONLY.)

Michigan
(Wheeled front end loaders ONLY.)

Samsung Heavy Industries, Co.
1 Lincoln Center, Suite 1650
Oak Brook Terrace, IL 60181
Phone: (708) 916-2365
(Wheeled front end loaders ONLY.)

Elliott Industrial Co.
1505 Foote Drive
Idaho Falls, ID 83401
Phone: (208) 523-9915

Case Power & Equipment
5666 N. Yellowstone Hwy.
Idaho Falls, ID 83401
Phone: (208) 523-5455

Rocky Mountain Machinery
2320 West 1500 South
Salt Lake City, UT 84104
Phone: (801) 972-3660

Kubota Sales & Service
3005 Stanley Avenue
Idaho Falls, ID 83401
Phone: (208) 529-5570

Central Equipment Co.
2700 1/2 S. 5th Avenue
Pocatello, ID
Phone: (208) 233-2850

INEL PROBLEM SITES:

Radioactive, underground storage tanks, aboveground storage tanks, and associated soil.

OU 1-05, TSF-06, TAN V-1, TAN V-2, TAN V-3, TSF-PM2A; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-31, CPP-78; OU 3-12, CPP-81, CPP-82; OU 3-13, CPP-39.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-03, TSF-38, WRTF-01; OU 1-04, LOFT-02; OU 2-07, TRA-036, TRA-38, TRA-39; OU 4-05, CFA-04, CFA-17; OU 4-06, CFA-06, CFA-43.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-13; OU 3-08, CPP-15; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06, CPP-09; OU 3-13, CPP-48; OU 5-12, PBF-08, PBF-10; OU 7-13, RWMC-04.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 1-06, LOFT-01, TSF-08; OU 3-11, CPP-45; OU 4-06, CFA-44; OU 4-09, CFA-10, CFA-26, CFA-42; OU 7-08, RI/FS.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29, CPP-35; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

Landfills.

OU 4-12, CFA-02, CFA-03.

PROBLEM AREAS/CONSTITUENTS:**Waste Types:**

Low level radioactive-noncompactible, combustible; Hazardous-organics, metals, wood, recyclables; Soil; Concrete; Municipal sanitary-trash, liquid; Mixed low level radioactive-metals; Indeterminate; Radioactive, mixed radioactive, hazardous-organics, transuranic Rocky Flats fire waste, Pu, and fuel end boxes.

Waste Form/Contaminants:

Debris-concrete, metals, glass, plastic, paper, rags, sweepings, vehicles, diatomaceous earth, wood; Lead chunks; Sludge; Sediment; Laboratory waste-liquid; Gravel; Concrete; Soils, Solid/¹³⁷Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ¹⁵⁴Eu, ¹¹⁰Ag, ²³⁹Pu, ²⁴⁰Pu (1pCi/g), ¹³⁴Cs, low levels of Pu, any metal or laboratory chemical, trivalent chromium, mercury, mercuric nitrate, nitric acid, fuel oil spill, lead, lead oxide, TCE, TCA, xylene in parts per billion, ⁶⁰Co and ¹³⁷Cs (1000pCi/g), mercury, lead, paint thinner, and diesel fuel.

SUBELEMENTS: Retrieval**ALTERNATIVES: Manual Excavation**

TECHNOLOGY: Manually Operated Backhoe

STATUS: Accepted

Currently accepted and proven technology used by the construction and demolition industries for selective excavation, trenching, larger excavation sites, and demolition operations. Application is directly related to the remediation of problems similar to the identified site specific work tasks.

There are several types of manual backhoes which are commercially available and technically proven. These would include the smaller wheeled (2-wheel and 4-wheel drive, rubber tired) and larger tracked backhoes. Typically the tracked backhoes are utilized for the larger equipment due to their ability to provide stability to the equipment chassis. Each of these types of manual backhoes have specific applications in which their physical characteristics will provide more efficient and cost effective excavation.

All of the manual backhoes are operated through hydraulic pressure systems. The next generation of backhoes operational cab is better designed for the operator (Ergonomics; seat comfort, control positions, viewing angles, etc.) and allows longer operation times with less operator fatigue. The next generation of backhoes have more operator/computer interface in which the operator instructs the computer to what type of operational mode to work in and the computer adjusts engine speeds for optimum utilization of excavator and fuel economy. Another area utilizing the computer equipment interface, is the overall operational smoothness and improved cycle speed (end cycle jerk dampened, track movement synchronized and tied to a single pedal, etc.) Serviceability is another item which received lots of attention (ease of access for field maintenance or repair work, standard maintenance work reduced, etc.).

SCIENCE AND TECHNOLOGY NEEDS:

No new scientific investigation and/or technological development is necessary to fully implement commercially available equipment sized to meet the identified site specific work tasks.

Each of these types of manual backhoes have a wide range of equipment sizes to meet the desired performance characteristics required for the particular work task and site physical conditions. An example of this would be the available sizes of backhoes. These range from the 600-pound walk behind type to the larger 150,000-pound type (these typically have bucket capacities of 2.5-7 cubic yards and can exert a digging force in excess of 70,000 pounds).

The manual backhoes also have a limited range of subsystem equipment sizes to meet the desired performance characteristics required. One of the major subsystems would include the track types and widths to be utilized with the chassis (e.g., shoe arrangement of the track one, two, or three, for traction in varying soil conditions, steel or rubber inserts for use off-road or on-road applications, wider tracks for softer soil conditions, etc.).

Another of the major subsystems would include the arm sizes to be utilized with the chassis, e.g., short, medium, and long second arms are available for heavy work applications, overall typical

operations, and extended reach light work applications respectively. These second member arm lengths range from under 6 feet to under 25 feet. These long second member arms also have associated a decreased digging force (ranging from approximately 46%-64% reductions).

One of the major subsystems which recently has had the largest growth in available types of equipment has been the work attachments. These would include the following types of attachments:

- Buckets Widths, sizes, and types (smooth faced, toothed faced, v-shaped, etc.) used for trenching or excavation operations.
- Compactors Wheeled and vibratory plate used to compact trenching backfill or structural backfill operations.
- Hydraulic Rams Hydraulic jackhammers used to break up concrete structures. (Typically pavement applications.)
- Shears Hydraulic shears used to down size larger steel structures vs. manual labor utilizing cutting torches.
- Pulverizers Hydraulic concrete crushers used to pulverize or downsize large concrete structures while cutting and sorting out reinforcing steel.
- Specialized Barrel handling, forks, grapples, etc.

There are many manufacturers of backhoe type excavators within the United States, including foreign Americanized companies. The "Buy American" philosophy should not bias the engineering decisions on the best equipment available. (Must consider many "American" manufacturers utilize large percentages of foreign made parts, e.g., CAT and CASE backhoes utilize Mitsubishi and Cummins engines while Link Belt utilizes Isuzu and Cummins engines, etc.).

IMPLEMENTATION NEEDS:

None required.

COMMENTS:

THE ER&WM D&D Projects Unit currently has a smaller tracked backhoe and a hydraulic shear attachment. The following are the major equipment specifications for reference (more detailed specifications can be obtained upon request):

CASE Model 688:

Operational Weight:	29,480 pounds
Counterweight	6,503 pounds
Breakout Force:	18,889 pounds

Engine:	4 cylinder, Case 4T-390 turbo-charged, diesel, 92hp@2,000rpm
Tracks:	24" wide, ground pressure 5.19 psi, sprocket drive w/hydraulic motors and planetary gear reduction.
Second Arm Length (Dipperstick):	8'8"
Maximum Reach at Grade Level:	27'2"
Maximum Digging Depth:	18'6"

The ER&WM D&D Projects Unit also currently has a smaller backhoe loader. The following are the major equipment specifications for reference (more detailed specifications can be obtained upon request):

CASE Model 680L

Operational Weight:	19,600 pounds
Breakout Force:	10,760 pounds
Engine:	4 cylinder, CASE 4-390 diesel, 75hp@2,200rpm
Drive System:	Four wheel drive, rubber tires
Second Arm Length (Extendahoe):	Variable
Maximum Reach at Grade Level:	25'5"
Maximum Digging Depth:	18'3"
Front Bucket:	1.5 cy (smooth)
Rear Bucket:	0.25 cy (toothed)

The ER&WM D&D Projects Unit has also recently procured (May, 1993) a 45,000 pound class tracked backhoe and another hydraulic shear/concrete crusher combination attachment. It was found that of all the equipment manufacturers for this class of tracked backhoe, only John Deere could claim to be "All American Made." This John Deere was only \$4,000 more than the next lowest competitor and was chosen based upon this "All American Made" claim. The following are the major equipment specifications for reference (more detailed specifications can be obtained upon request):

John Deere Model 690E LC

Operational Weight:	45,120 pounds
Breakout Force:	28,180 pounds
Engine:	4 cylinder, JD 6068T turbocharged, diesel, 130hp@2,000rpm

Tracks:	30" wide, ground pressure 4.92psi, sprocket drive w/hydraulic motors and planetary gear reduction
Second Arm Length (Dipperstick):	7'3"
Maximum Reach at Grade Level:	29'8"
Maximum Digging Depth:	21'8"

EVALUATOR: Donald J. Kenoyer	Phone (208) 526-9837
	FAX (208) 526-2714

REFERENCES:

The following is a listing of the major manufacturers of backhoes and does not attempt to be a complete listing.

EXCAVATION EQUIPMENT MANUFACTURER

Caterpillar, Inc..
P.O. Box 10097
Peoria, IL 61612-8818
Phone: (309) 675-1000

Dresser Industries
P.O. Box 718
Dallas, TX 75221
Phone: (214) 740-6000

Gradall Co.
406 Mill Avenue SW
New Philadelphia, OH 44663
Phone: (216) 339-2211

Hitachi Constr. Machinery
(America) Corp.
20419 Imperial Valley Dr.
Houston, TX 77073
Phone: (713) 821-2400

Hyundai Construction Equipment
1162 Tower Lane
Benseville, IL 60106
Phone: (708) 766-0380

LOCAL DISTRIBUTOR

Western States Equipment
2405 Garrett Way
Pocatello, ID 83401
Phone: (800) 832-2287

Arnold Machinery Co.
3330 N. Yellowstone Hwy.
Idaho Falls, ID 83401
Phone: (208) 523-0822

Western Road Machinery
970 West Cedar
Pocatello, ID
Phone: (208) 232-6254

Arnold Machinery Co.
3330 N. Yellowstone Hwy.
Idaho Falls, ID 83401
Phone: (208) 523-0822

Clyde-West
13805 NE Sandy Boulevard
Portland, OR 97230
Phone: (503) 252-5933

John Deere & Co.
John Deere Road
Moline, IL 61265
Phone: (309) 765-8000
(Straight track dozers ONLY.)

J.I. Case Co.
900 Alderson Street
Schofield, WI 54476
Phone: (715) 359-6511

Kobelco America Inc.
10515 Harwin Drive
Houston, TX 77036
Phone: (713) 981-4050

Komatsu Equipment

Koehring
Waverly, OH

Kubota Tractor Corp.
550 W. Artesia Blvd.
Compton, CA 90220
Phone: (310) 537-2531

Liebherr America Inc.
4100 Chestnut Avenue
Newport News, VA 23605
Phone: (804) 245-5252

Link-Belt Construction Equip.
2651 Palumbo Drive
Lexington, KY 40509
Phone: (606) 263-5200

Samsung Heavy Industries
1 Lincoln Center, Suite 1650
Oak Brook Terrace, IL 60181
Phone: (708) 916-2365

Elliott Industrial Co.
1505 Foote Drive
Idaho Falls, ID 83401
Phone: (208) 523-9915

Case Power & Equipment
5666 N. Yellowstone Hwy.
Idaho Falls, ID 83401
Phone: (208) 523-5455

Cate Idaho Equipment Co.
S. 5th Ave. & Gateway Dr.
Pocatello, ID
Phone: (801) 972-3660

Rocky Mountain Machinery
2320 W. 1500 South
Salt Lake City, UT 84104
Phone: (801) 972-3660

Kubota Sales & Service
3005 Stanley Avenue
Idaho Falls, Idaho
Phone: (208) 529-5570

Central Equipment Co.
2700 1/2 S. 5th Avenue
Pocatello, ID
Phone: (208) 233-2850

Central Equipment Co.
2700 1/2 S. 5th Ave.
Pocatello, ID
Phone: (208) 233-2850

Yanmar Diesel America Corp.
901 Corporate Grove Dr.
Buffalo Grove, IL 60089
Phone: (708) 541-1900

They only produce engines
in the US and ALL
equipment manufacturing
is accomplished in Japan.

INEL PROBLEM SITES:

Radioactive, underground storage tanks, aboveground storage tanks, and associated soil.

OU 1-05, TSF-06; OU 3-07, CPP-26, CPP-31; OU 3-12, CPP-81, CPP-82; OU 3-13, CPP-39.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-04, LOFT-02.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-06, TSF-07, OU 3-09, CPP-04, CPP-05, CPP-09.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 1-06, LOFT-01, OU 7-08, RI/FS.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29; OU 3-09, CPP-78; OU 3-12, CPP-80.

Landfills.

OU 4-12, CFA-02, CFA-03.

PROBLEM AREAS/CONSTITUENTS:**Waste Types:**

Low-level radioactive, noncompactible; Mixed low-level radioactive-noncompactible, metals; Hazardous-metals, organics; Municipal sanitary; Indeterminate; Mixed low-level radioactive; Radioactive, mixed radioactive, hazardous-organics, transuranic Rocky Flats fire waste, Pu, fuel end boxes.

Waste Form/Contaminants:

Debris-concrete, metal, paper, plastic, trash, sweepings, rags, vehicles, diatomaceous earth, wood; Soil; Concrete; Sediment; Laboratory waste-liquid; Sludge/¹³⁷Cs, ⁶⁰Co, ⁹⁰Sr, low levels of Pu, mercuric nitrate, nitric acid; heavy hydrocarbons, Pb, lead, mercury, chromium, trivalent chromium, Hg, TCE, TCA, xylene in parts per billion, (100pCi/g), ²³⁹Pu, ²⁴⁰Pu, (1pCi/g), ¹⁵⁴Eu (5pCi/g), toluene, carbon tetrachloride, Pu, diesel fuel, beryllium, and trichloroethane.

SUBELEMENTS: Retrieval

ALTERNATIVES: Excavation Equipment

TECHNOLOGY: Manually Operated Motor Grader

STATUS: Accepted

Currently accepted and proven technology used by the construction and demolition industries for shallow excavation and/or grading operations. Application is directly related to the remediation of problems similar to the identified site specific work tasks.

SCIENCE AND TECHNOLOGY NEEDS:

No new scientific investigation and/or technological development is necessary to fully implement commercially available equipment, sized to meet the identified site specific work tasks.

These motor graders have a wide range of equipment sizes to meet the desired performance characteristics required for the particular work task and site physical conditions. An example of this would be the available sizes of motor graders. These range from the smaller 27,800-pound class to the larger 32,400-pound class (these typically have an associated power of 152 hp to 215 hp).

The manual motor graders also have a wide range of subsystem equipment sizes to meet the desired performance characteristics required. One of the major subsystems would include the chassis types; fixed or articulated. Almost all manufacturers now utilize articulated chassis types because of improved maneuverability and operational performance.

Another of the major subsystems would include the drive-train to be utilized with the chassis, e.g., four-wheel drive vs. all-wheel drive. The all-wheel drive subsystem is a recent development in motor grader manufacturing. Typically, the four rear wheels provided all the drive train power, however, through a syncromeshed hydrostatic transfer system to the front wheels, an all-wheel drive is developed. This all-wheel drive subsystem offers improved traction and operational performance.

Another of the major subsystems would include the blade articulation (range of motion) to be utilized with the chassis, e.g., limited blade swing vs. unlimited blade swing. The unlimited blade swing allows the blade assembly to be rotated 90° to the vertical on either side of the chassis. Almost all manufacturers of motor graders now utilize the unlimited blade swing types because of improved adaptability to adverse grading conditions and operational performance.

One of the major subsystems which recently has had the largest growth in available types of equipment has been the work attachments. These would include the following types of attachments:

- **Blades** Widths, sizes, and types (smooth faced, steel faced, rubber faced, additional plow faces snow plowing, etc.).
- **Rippers** Widths, sizes, and types for front, mid-range, or rear mounting to chassis.
- **Tires** Widths, sizes, and types and associated accessories, i.e., such as chains for traction, chain mesh for protection, etc.

There are many manufacturers of motor graders within the United States, including foreign Americanized companies. The "Buy American" philosophy should not bias the engineering decisions on the best equipment available.

IMPLEMENTATION NEEDS:

A water spray system for confinement of radioactive contaminated materials (loose soil and dust) would need to be developed. This could simply be a water tank, hose, and spray nozzles attached ahead and/or behind the blade. Another alternative would be to simply utilize the typical construction water truck to keep soil moist ahead of the grading and collection operation (keep it simple).

EVALUATOR: Donald J. Kenoyer Phone (208) 526-9837
FAX (208) 526-2714

REFERENCES:

The following is a listing of the major manufacturers of motor graders and does not attempt to be a complete listing.

EXCAVATION EQUIPMENT MANUFACTURER

Caterpillar, Inc.
P.O. Box 10097
Peoria, IL 61612-8818
Phone: (309) 675-1000

Champion Road Machinery Ltd.
P.O. Box 10
160 Maitland Road
Goderich, Ontario, Canada N7A 3Y6
Phone: (519) 524-2601

Dresser Industries
P.O. Box 718
Dallas, TX 75221
Phone: (214) 740-6000

Gehl Company
143 Water Street
West Bend, WI 53095
Phone: (414) 344-6615

John Deere & Co.
John Deere Road
Moline, IL 61265
Phone: (309) 765-8000

LOCAL DISTRIBUTOR

Western States Equipment
2405 Garrett Way
Pocatello, ID 83401
Phone: (800) 832-2287

Central Equipment Co.
2700 1/2 S. 5th Avenue
Pocatello, ID
Phone: (208) 233-2850

Arnold Machinery Co.
3330 N. Yellowstone Hwy.
Idaho Falls, ID 83401
Phone: (208) 523-0822

Elliott Industrial Co.
1505 Foote Drive
Idaho Falls, ID 83401
Phone: (208) 523-9915

J.I. Case Co.
900 Alderson Street
Schofield, WI 54476
Phone: (715) 359-6511

Case Power & Equipment
5666 N. Yellowstone Hwy.
Idaho Falls, ID 83401
Phone: (208) 523-5455

Liebherr America Inc.
4100 Chestnut Avenue
Newport News, VA 23605
Phone: (804) 245-5252

Central Equipment Co.
2700 1/2 S. 5th Avenue
Pocatello, ID
Phone: (208) 233-2850

Taylor Machine Works, Inc.
650 North Church Avenue
Louisville, MS 39339-2017
Phone: (601) 773-3421

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.

OU 1-05, TSF-06; OU 3-07, CPP-26, CPP-31; OU 3-12, CPP-81, CPP-82; OU 3-13, CPP-39.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-04, LOFT-02; OU 2-07, TRA-36, TRA-39; OU 4-05, CFA-04.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-06, TSF-07; OU 3-09, CPP-04, CPP-05, CPP-09.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 1-06, LOFT-01; OU 7-08, RI/FS.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29; OU 3-09, CPP-78; OU 3-12, CPP-80.

Landfills.

OU 4-12, CFA-02, CFA-03.

PROBLEM AREAS/CONSTITUENTS:**Waste Types:**

Low-level radioactive, noncompactible; Mixed low-level radioactive-noncompactible, metals; Hazardous-metals, organics; Municipal sanitary; Indeterminate; Mixed low level radioactive; Radioactive, mixed radioactive, hazardous-organics, transuranic Rocky Flats fire waste, Pu, fuel end boxes.

Waste Form/Contaminants:

Debris-concrete, metal, paper, plastic, trash, sweepings, rags, vehicles, diatomaceous earth, wood; Soil; Concrete; Sediment; Laboratory waste-liquid; Sludge/ ^{137}Cs , ^{60}Co , ^{90}Sr , low levels of Pu, mercuric nitrate, nitric acid, heavy hydrocarbons, Pb, lead, mercury, chromium, trivalent chromium, Hg, TCE, TCA, xylene in parts per billion, (1000pCi/g), ^{239}Pu , ^{240}Pu , (1pCi/g), ^{154}Eu , (5pCi/g), toluene, carbon tetrachloride, diesel fuel, beryllium, and trichloroethane.

SUBELEMENTS: Retrieval

ALTERNATIVES: Excavation Equipment

TECHNOLOGY: Manually Operated Dozer

STATUS: Accepted

Currently accepted and proven technology used by the construction and demolition industries for larger excavation and/or pushing operations. Application is directly related to the remediation of problems similar to the identified site specific work tasks.

There are several types of manual dozers which are commercially available and technically proven. These would include the straight track and modified track dozers. Typically the modified track dozers are utilized for the larger equipment due to their ability to provide improved operational performance. Each of these types of manual dozers have specific applications in which their physical characteristics will provide more efficient and cost effective excavation.

All of the manual dozers are operated through hydraulic pressure systems. The next generation of dozers operational cab is better designed for the operator (Ergonomics; seat comfort, control positions, viewing angles, etc.) and allows longer operation times with less operator fatigue. The next generation of dozers have more operator/computer interface in which the operator instructs the computer to what type of operational mode to work in and the computer adjusts engine speeds for optimum utilization of excavator and fuel economy. Serviceability is another item which received lots of attention (ease of access for field maintenance or repair work, standard maintenance work reduced, etc.)

SCIENCE AND TECHNOLOGY NEEDS:

No new scientific investigation and/or technological development is necessary to fully implement commercially available equipment, sized to meet the identified site specific work tasks.

Each of these types of manual dozers have a wide range of equipment sizes to meet the desired performance characteristics required for the particular work task and site physical conditions. An example of this would be the available sizes of manual dozers. These range from the smaller 17,000-pound class, to the medium 48,000-pound class, to the super large 222,000-pound type (these typically have blade capacities ranging from 1.8 cy to 42.4 cy and can exert a ripping pryout force ranging up to 130,000 lbs.)

The manual dozers also have a limited range of subsystem equipment sizes to meet the desired performance characteristics required. One of the major subsystems would include the track subsystems including track arrangement and track types/widths. The two track arrangements are straight and modified (triangular shaped). The track types and widths to be utilized with the chassis (e.g., shoe arrangement of the track one, two, or three, for traction in varying soil conditions, steel or rubber inserts for use off road or on road applications, wider tracks for softer soil conditions, etc.)

One of the major subsystems which recently has had the largest growth in available types of equipment has been the work attachments. These would include the following types of attachments:

- Blades Widths, sizes, and types. (Smooth faced, steel faced, rubber faced, additional plowfaces, snow plowing, etc.)
- Specialized (Land clearing rakes, plow disks, subsoilers, winches, cable layers, etc.)

There are many manufacturers of dozers within the United States, including foreign Americanized companies. The "Buy American" philosophy should not bias the engineering decisions on the best equipment available.

IMPLEMENTATION NEEDS:

A water spray system for confinement of radioactive contaminated materials (loose soil and dust) would need to be developed. This could simply be a water tank, hose, and spray nozzles attached ahead and/or behind the blade. Another alternative would be to simply utilize the typical construction water truck to keep soil moist ahead of the grading and collection operation (keep it simple).

COMMENTS:

None.

EVALUATOR: Donald J. Kenoyer

Phone (208) 526-9837

FAX (208) 526-2714

REFERENCES:

The following is a listing of the major manufacturers of dozers and does not attempt to be a complete listing:

EXCAVATION EQUIPMENT MANUFACTURER

Caterpillar, Inc.
P.O. Box 10097
Peoria, IL 61612-8818
Phone: (309) 675-1000
(Straight and modified track
dozers. ONE OF THE LARGEST
DOZER MANUFACTURERS IN THE
USA.)

Dresser Industries
P.O. Box 718
Dallas, TX 75221
Phone: (214) 740-6000
(Straight and modified track
dozers.)

FiatAllis

(Straight track dozers ONLY.)

LOCAL DISTRIBUTOR

Western States Equipment
2405 Garrett Way
Pocatello, ID 83401
Phone: (800) 832-2287

Arnold Machinery Co.
3330 N. Yellowstone Hwy.
Idaho Falls, ID 83401
Phone: (208) 523-0822

John Deere & Co.
John Deere Road
Moline, IL 61265
Phone: (309) 765-8000
(Straight track dozers ONLY.)

J.I. Case Co.
900 Alderson Street
Schofield, WI 54476
Phone: (715) 359-6511
(Straight track dozers ONLY.)

Komatsu Equipment

(Straight track dozers ONLY.)

Liebherr America Inc.
4100 Chestnut Avenue
Newport News, VA 23605
Phone: (804) 245-5252

Elliott Industrial Co.
1505 Foote Drive
Idaho Falls, ID 83401
Phone: (208) 523-9915

Case Power Equipment
5666 N. Yellowstone Hwy.
Idaho Falls, Idaho 83401
Phone: (208) 523-5455

Rocky Mountain Machinery
2320 W. 1500 South
Salt Lake City, UT 84104
Phone: (801) 972-3660

Central Equipment Co.
2700 1/2 S. 5th Avenue
Pocatello, ID
Phone: (208) 233-2850

INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 1-04, LOFT-02.

PROBLEM AREAS/CONSTITUENTS:**Waste Types:**

Hazardous-metals.

Waste Form/Contaminants:

Soil/Lead, mercury.

SUBELEMENTS: Retrieval

ALTERNATIVES: Trenching Equipment

TECHNOLOGY: Manually Operated Trencher

STATUS: Accepted

Specialized trenching equipment is typically utilized for excavation of buried pipelines at contaminated facilities.

Currently accepted and proven technology used by the construction and demolition industries for trenching operations. Application is directly related to the remediation of problems similar to the identified site specific work tasks.

SCIENCE AND TECHNOLOGY NEEDS:

No new scientific investigation and/or technological development is necessary to fully implement commercially available equipment, sized to meet the identified site specific work tasks.

IMPLEMENTATION NEEDS:

A water spray system for confinement of radioactive contaminated materials (loose soil and dust) would need to be developed. This could simply be a water tank, hose, and spray nozzles attached ahead and/or behind the trencher wheel or bar.

Another alternative would be to simply utilize the typical construction water truck to keep soil moist, ahead of the grading and collection operation (keep it simple).

COMMENTS:

This type of equipment was not expanded upon, as to types of equipment and listing of equipment manufacturers, since it was not shown that there was a real need for this specific type of equipment. Most trenching type operations can be accomplished through the utilization of backhoe type equipment.

EVALUATOR: Donald J. Kenoyer

Phone (208) 526-9837

FAX (208) 526-2714

REFERENCES:

None provided. For more information, contact the above evaluator.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.

OU 1-05, TSF-06; OU 2-05, TRA-15; OU 3-07, CPP-26, CPP-28, CPP-31, CPP-79; OU 3-12, CPP-81, CPP-82; OU 3-13, CPP-39.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38, TSF-03.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-13; OU 3-08, CPP-15; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06, CPP-09; OU 3-13, CPP-48; OU 5-12, PBF-08; OU 7-13, RWMC-04.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 7-08, RI/FS.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-29, CPP-35, CPP-36; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58; OU 3-12, CPP-80.

Unexploded naval ordnance.

OU 10-03, ORD.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low level radioactive-noncompactible, combustible; Hazardous-organics, metals; Municipal sanitary; Mixed low level radioactive-metals; Indeterminate; Radioactive, mixed radioactive, hazardous-organics, transuranic, Rocky Flats fire waste, Pu, fuel end boxes.

Waste Form/Contaminants:

Debris-concrete, metals, paper, plastic, glass, sweepings, trash, rags, sweepings, vehicles, diatomaceous earth, wood, metal; Soil; Concrete; Sediment; Laboratory waste-liquid; Sludge; Solid/¹³⁷Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ¹³⁴Cs, ¹⁴⁴Cs, ¹⁵⁴Eu, ¹¹⁰Ag, low levels of Pu, any metal or laboratory chemical, heavy hydrocarbons, Pb, lead, mercury, chromium, Hg, TCE, TCA, xylene in parts per billion, ¹³⁷Cs (1000pCi/g), ²³⁹Pu, ²⁴⁰Pu (1pCi/g), (5pCi/g), toluene, carbon tetrachloride, Pu, diesel fuel, beryllium, and trichloroethane.

SUBELEMENTS: Retrieval

ALTERNATIVES: Remote Excavation Equipment

TECHNOLOGY: Teleoperated Excavation Equipment

STATUS: Demonstration, testing and evaluation needed

Currently, there is a lot of work being accomplished in this area of technology, specifically remotely operated equipment. Several of the larger excavation equipment manufacturers have been actively involved with the development of these remotely operated equipment (these are listed below). EG&G Idaho, Inc., is currently involved in the development of remotely operated excavation equipment, specifically the development of a CAT 235D Front Shovel (Mass Excavator) with Caterpillar. EG&G Idaho is also involved in the "Integrated Demonstration" Program which will be demonstrating a remotely operated backhoe-type excavator in the summer of 1993, at the INEL.

The remotely operated excavation equipment is fairly expensive compared to the commercially available excavation equipment (\$2-\$4 million vs. \$200-\$400 thousand...approx. 10x). This equipment has been developed to the point that this equipment should no longer be considered "Research and Development" type equipment. (There are various remote type equipment developed for the United States military which is in use at this time), but rather equipment which needs to be proven in a production type environment.

There needs to be a "Free Exchange" of technological information between the government agencies such as the DOE and DOD to ensure that there is no redoubling of efforts to achieve the same end results (wasting time and money, which nobody has enough of).

SCIENCE AND TECHNOLOGY NEEDS:

Most of the information related to the remotely operated excavation equipment tends to support the development of the larger scale equipment (e.g. the CAT 235D and 245D Front Shovels are in the 145,000 lb. class; largest class of excavators made by Caterpillar). Most of the demolition type equipment developed for the United States Army and Air Force were larger class equipment also.

Martin Marietta has developed some smaller remotely operated equipment (Mainly forward observation and survey equipment). These remotely operated survey equipment have been utilized by the nuclear industry to perform plant surveillances. The tracked model can climb and assent stairways and the wheeled model has a manipulator arm which may be utilized for taking samples.

The teleoperated and the telerobotically operated excavators are a relatively new technology. These remotely operated excavators have been demonstrated and placed in actual use in such diverse activities as mines, unexploded ordnance, rapid runway repair, and retrieval of hazardous materials. A number of companies have been engaged in the development of remotely operated excavators and several have been produced and operated by industry and the United States air Force (USAF).

IMPLEMENTATION NEEDS:

The INEL "Integrated Demonstration" Program which will be demonstrating a remotely operated backhoe-type excavator in the summer of 1993, should bring forth many of the known site specific requirements and implementation needs.

COMMENTS:

Considering the costs involved related to the remotely operated excavation equipment, this equipment should only be considered when radiological fields and other hazardous materials present considerable health risks to the personnel performing the work tasks. In lower radiological fields, shielded manually operated excavation equipment may be utilized.

EVALUATOR: Donald J. Kenoyer

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FAX (208) 2714

REFERENCES:

There are numerous manufacturers that are or have been engaged in the design and development of remotely operated excavators. The following is a list of the major excavator manufacturers:

EXCAVATION EQUIPMENT MANUFACTURER/RESEARCHER CONTACT

Bethos, Inc.
North Falmouth, MA

Kevin McCarthy
(800) 446-1222

Carnegie-Mellon University
Pittsburgh, PA

Dr. William Whitaker
(412) 268-6559

Caterpillar, Inc.
Peoria, IL

Paul Pemberton
(309) 675-4301

Dresser Industries, Inc.
Marion Division
Marion, OH

Thomas Files
(614) 383-5211

Foster-Miller, Inc.
Waltham, MA

Dick Atkinson
(617) 890-3200

International Submarine
Engineering LTD.
Port Coquitlam, B.C. Canada

James A. Farelane
(604) 937-3421

J.I. Case Co.
Drott Division
Schofield, WI

John Deere & Co.
Moline, IL

William P. Wohlford
(309) 765-3738

Kobelco America Inc.
10515 Harwin Drive
Houston, TX 77036
Phone: (713) 981-4050

Rich Goeffert
(713) 981-4050

Kraft Telerobotics, Inc.
Overland Park, KS

Steve Habur
(913) 894-9022

Martin Marietta Aero &
Naval Systems
Baltimore, MD

Dr. Von Jennings
(410) 682-0892

RSI Research LTD.
Sidney, B.C. Canada

University of Florida
Gainsville, FL

Dr. Drane
(904) 392-0814

NOTE: The above table should be validated since two initial contacts revealed substantial changes to the contractors ability to perform remote or robotics research.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.

OU 1-05, TSF-06; OU 2-05, TRA-15; OU 3-07, CPP-28, CPP-31, CPP-79.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 2-07, TRA-36, TRA-39.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 2-09, TRA-07; OU 3-08, CPP-15; OU 3-09, CPP-06.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-35; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22;

OU 3-11, CPP-58

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low level radioactive-noncompactible; mixed low level radioactive-noncompactible; hazardous-metals; municipal sanitary.

Waste Form/Contaminants:

Debris-concrete, metals, paper, plastic, sweepings, trash; concrete; soil; wood/¹³⁷Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹⁵⁴Eu, ¹¹⁰Ag; low levels of Pu, mercuric nitrate, nitric acid, chromium, and trivalent chromium.

SUBELEMENTS: Retrieval**ALTERNATIVES:** Scabbling Equipment**TECHNOLOGY:** Manually Operated Scabbler

This is an abrasive device (electric or pneumatic) which is used to remove contamination from concrete and metal by chipping away the surface of the material.

STATUS: Accepted

Currently accepted and proven technology used by the construction and demolition industries for selective size reduction and other demolition operations. Application is directly related to the remediation of problems similar to the identified site specific work tasks.

EG&G Idaho, Inc., ER&WM D&D Projects Unit is investigating the utilization of other surface decontamination systems such as the CO² and H₂O high pressure blast. These systems have been utilized by other nuclear sites for the removal of surface contamination and have been very productive and successful. WINCO and EG&G Idaho are currently investigating the utilization of

a CO² high pressure blast system to be established at the Idaho Chemical Processing Plant (ICPP) for the decontamination of lead materials.

SCIENCE AND TECHNOLOGY NEEDS:

No new scientific investigation and/or technological development is necessary to fully implement commercially available equipment, sized to meet the identified site specific work tasks.

IMPLEMENTATION NEEDS:

Contamination collection barrels, Rough/HEPA filters, and vacuum systems would need to be supplied/procured for this operation. Electrical and air supply systems would be required for the operation of this remote or manual equipment.

COMMENTS:

The Remotely Operated Scarifier produced by Pentek has a very high rate of floor scarifying capability (3/16" depth removed on 20,000 sf in 155 hours of operation) and is virtually a "dust free" system (e.g. personnel are not required to wear face masks). For larger floor area decontamination operations, this system would be well suited for use at the INEL. The "MOOSE"TM is available for rental from Pentek with qualified operator for approximately \$2,500 per day.

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REFERENCES:

The Con Expo '93 exhibited a wide variety of concrete grinders, but there were no hydraulic or pneumatic multi-head scabblers. There was, however, one vacuum blasting system there which could be of interest, the GOFF Blast Cleaning Equipment (P.O. Box 1607, Seminole, OK 74868, Phone (405) 382-6900). This equipment has been utilized quite heavily by the nuclear plants according to the exhibitor representative for concrete floor decontamination work. This equipment has a self-contained abrasive recycling system and ventilation (dust collection) system which makes this ideal to nuclear applications.

In conjunction with the GOFF Blast Cleaning Equipment, SASE Company, Inc. (P.O. Box 81003, Seattle, WA 98108, Phone (206) 762-0744 or (800) 522-2606) carries Von Arx Surface Preparation Equipment which include hand-held and floor model pneumatic scabblers which contain the typical multi-point multiple head system.

In another related research project, scabblers were discussed in some detail and a specific reference was made to a "Remotely Operated Scarifier" (courtesy of Pentek Corp., USA and the Electric Power Research Institute, USA). Pentek Corp. (1026 Fourth Avenue, Coraopolis, PA 15108-1659 Phone (412) 262-0725), carries a wide variety of scabblers (electric and pneumatic) and dust control systems. These dust control systems include HEPA filters, vacuum and drumming systems. Also, the Model 9 air-driven version floor scabbler system was chosen for use at the Savannah River Site (SRS).

Additional Research should be accomplished with PENTEK on their work with "Remote Scabblers" since the 1988 report written.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.

OU 1-05, TSF-06; OU 2-05, TRA-15; OU 3-07, CPP-28, CPP-31, CPP-79.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 2-07, TRA-36, TRA-39.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 2-09, TRA-07; OU 3-08, CPP-15; OU 3-09, CPP-06.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-35, CPP-36; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22; OU 3-11, CPP-58

PROBLEM AREAS/CONTAMINANTS:**Waste Form:**

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible;

Hazardous-metals; Municipal sanitary.

Waste Type/Contaminants:

Debris-concrete, soil, metals, paper, plastic, sweepings, trash; Concrete; Soil/¹³⁷Cs, ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ¹³⁴Cs, ¹⁴⁴Cs, ¹⁵⁴Eu, ¹¹⁰Ag, low levels of Pu, mercuric nitrate, nitric acid, and chromium.

SUBELEMENTS: Retrieval**ALTERNATIVES:** Size Reduction Equipment**TECHNOLOGY:** Hydraulic-Powered Shear Attachment (Utilized with Backhoe)**STATUS:** Accepted

Currently accepted and proven technology used by the construction and demolition industries for selective size reduction and other demolition operations. Application is directly related to the remediation of problems similar to the identified site specific work tasks.

There are several manufacturers of hydraulic powered shears and concrete pulverizers which are commercially available and technically proven. All of these hydraulic powered shears and concrete pulverizers are operated through single or double hydraulic piston-drive systems which are supplied by the supporting equipment (typically a backhoe or front end loader).

SCIENCE AND TECHNOLOGY NEEDS:

No new scientific investigation and/or technological development is necessary to fully implement commercially available equipment, sized to meet the identified site specific work tasks. These hydraulic powered shears have a wide range of equipment sizes to meet the desired performance

characteristics required for the particular work task and site physical conditions. The particular shear size must also be matched to the support equipment size, e.g., and 11,000 lb. shear, utilized on the second member of a backhoe, would require a 70,000 lb. class backhoe, vs. an 11,000 lb. shear, utilized on the third member of a backhoe, would require a 120,000 lb. class backhoe, etc.

The hydraulic powered shears vary in sizes and types and can be matched to the project specific requirements. These sizes range from the smaller 950 lb. class, to the medium 11,400 lb. class, to the super-large 58,000 lb. class. These shears do not carry a shearing force rating due to the nonstandardized methods of measurement (e.g., where in the throat does one take the shear force reading?, etc.).

The hydraulic powered concrete pulverizers vary in sizes and types and can be matched to the project specific requirements. These sizes range from the smaller 400 lb. class, to the large 16,000 lb. class. These concrete pulverizers do not carry a crushing force rating due to the nonstandardized methods of measurement (e.g., where in the throat does one take the crushing force reading?, etc.).

IMPLEMENTATION NEEDS:

Hydraulic Powered Concrete Pulverizer: A water spray system for confinement of radioactive contaminated materials (concrete debris) would need to be developed. This could simply be a labor craft personnel with a water hose and spray wand (keep it simple).

COMMENTS:

The ER&WM D&D Projects Unit currently has a smaller hydraulic powered shear which is utilized with the CASE Model 688 tracked backhoe (29,400 lb. class backhoe). The following are the major equipment specifications for reference (more detailed specifications can be obtained upon request):

LaBounty Model MSD 15R

Attachment Weight:	3,500 lbs.
2nd Member Use Required	
Equipment Weight:	20,000lb.class
Shear Opening:	18"
Throat Distance:	20"
Shear Force:	ft., lbs.

One of the "Lessons Learned" in the procurement of the first hydraulic powered shear by the ER&WM D&D Projects Unit was the needed specification for "Quick-Disconnect Fittings" for the hydraulic hose systems. These quick-disconnect fittings greatly speed up the changeout process when working with the attachment and the support equipment.

The ER&WM D&D Projects Unit has also recently procured (May, 1993) a 45,000-pound class tracked backhoe and another hydraulic shear/concrete crusher combination attachment. The hydraulic powered shear/concrete crusher combination (interchangable jaws utilizing the same

basic hydraulic attachment) is a LaBounty. The following are the major equipment specifications for reference (more detailed specifications can be obtained upon request):

LaBounty Model UP20 (Universal Processor)

Attachment Weight:	4,100 lbs.
3rd Member Use Required	
Equipment Weight:	42,000lb. class
Shear Opening:	20"
Pulverizer Opening:	26"
Throat Distance:	19"
Cracker Opening:	42"
Throat Distance:	23"
Shear Force:	ft., lbs.

EVALUATOR: Donald J. Kenoyer Phone (208) 526-9837
FAX (208) 526-2714

REFERENCES:

There are many manufacturers of hydraulic powered shears and concrete pulverizers within the United States, including foreign Americanized companies. The "Buy American" philosophy should not bias the engineering decisions on the best equipment available.

The following is a listing of the major manufacturers of hydraulic powered shears and concrete pulverizers and does not attempt to be a complete listing:

<i>ATTACHMENT EQUIPMENT MANUFACTURER</i>	<i>LOCAL DISTRIBUTOR</i>
JRB Company Inc. P.O. Box 9445 Akron, OH 44305 Phone (216) 733-6800	Arnold Machinery Co. 3330 N. Yellowstone Hwy. Idaho Falls, ID Phone (208) 523-0822
LaBounty Manufacturing Div. 100 State Road Two Two Harbors, MN 55616 Phone (218) 834-2123	Arnold Machinery Co. P.O. Box 30020 2475 W. 2100 So. Salt Lake City, UT 84130 Phone (801) 972-4000
Stanley Hydraulic Tools 3810 SE Naef Road Milwaukie, OR 97267 Phone (503) 659-5660	Case Power & Equipment 5666 N. Yellowstone Hwy. Idaho Falls, ID 83401 Phone (208) 523-5455

Tramac Corporation
7 Emery Avenue
Rudolph, NJ 07869
Phone (201) 361-0490

Arnold Machinery Co.
3330 N. Yellowstone Hwy.
Idaho Falls, ID
Phone (208) 523-0822

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.

OU 3-07, CPP-28, CPP-31, CPP-79.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 2-07, TRA-36, TRA-39.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 2-09, TRA-07; OU 3-08, CPP-15; OU 3-09, CPP-06.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-35; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22;

OU 3-11, CPP-58.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; Mixed low-level radioactive-noncompactible;

Hazardous-metals; Municipal sanitary.

Waste Form/Contaminants:

Soil; Concrete; Debris-paper, plastic, wood/⁹⁰Sr, ¹³⁷Cs, low levels of Pu, mercuric nitrate, nitric acid, chromium, and trivalent chromium.

SUBELEMENTS: Retrieval

ALTERNATIVES: Size Reduction Equipment

TECHNOLOGY: Manually Operated Concrete Saw

STATUS: Accepted

Currently accepted and proven technology used by the construction and demolition industries for selective size reduction and other demolition operations. Application is directly related to the remediation of problems similar to the identified site specific work tasks.

SCIENCE AND TECHNOLOGY NEEDS:

No new scientific investigation and/or technological development is necessary to fully implement commercially available equipment, sized to meet the identified site specific work tasks.

There were 17 exhibitors at the Con Expo '93 for concrete saws and concrete sawing applications. These were only investigated for new technology applications into concrete sawing techniques. Prior D&D Unit experience with large concrete sawing applications lessons learned, directs the utilization of concrete sawing subcontractors rather than INEL crafts to accomplish the work task.

However, there was some new technology which may be useful for applications at the INEL on smaller concrete cutting/sawing applications. This was the pneumatic "Concrete Diamond Chain Saw." The main advantage to this system is the light weight, maneuverability, and ability to nose-in a cut and cut square holes with no overcut. There are several manufactures of this type of equipment and are listed in the references below.

IMPLEMENTATION NEEDS:

Portable vacuum, air, and water supply systems are needed to support this type of concrete cutting operations. Most of the concrete cutting systems are powered by gasoline engines and some have dust collection systems and/or vacuum systems.

COMMENTS:

The previous lessons learned by the EG&G D&D Projects Unit for prior D&D projects which included concrete cutting in high volumes, indicates that this type of work should be subcontracted to concrete cutting specialty contractors. The larger concrete cutting equipment is too specialized and costly to justify procurement and the relating personnel training. The smaller portable chain saw type concrete cutter has a far wider range of potential applications for D&D Projects related type work tasks.

EVALUATOR: Donald J. Kenoyer

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FAX (208) 526-2714

REFERENCES:

Stanley Hydraulic Tools, Division of Stanley Works,
3810 SE Naef Road, Milwaukie, OR 97267-5698, Phone
(503) 659-5660.

Oregon Cutting Systems, 4909 SE International Way,
Portland, OR 97222, Phone (503) 653-4518.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.

OU 1-05, TSF-06; OU 2-05, TRA-15; OU 3-07, CPP-28, CPP-31, CPP-79.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 2-07, TRA-36, TRA-39.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 2-09, TRA-07; OU 3-08, CPP-15; OU 3-09, CPP-06.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-35; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22;

OU 3-11, CPP-45

PROBLEM AREAS/CONTAMINANTS:

Waste Form:

Low-level radioactive-noncompactible; Mixed low level radioactive-noncompactible;

Hazardous-metals; Municipal sanitary.

Waste Type/Contaminants:

Debris-concrete, soil, paper, plastic, sweepings, trash; Concrete; Soil; Wood/¹³⁷Cs ⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ¹³⁴Cs, ¹⁴⁴Cs, ¹⁵⁴Eu, ¹¹⁰Ag, low levels of Pu, nitrate, nitric acid, chromium, and trivalent chromium.

SUBELEMENTS: Retrieval

ALTERNATIVES: Size Reduction Equipment

TECHNOLOGY: Manually Operated Hydraulic Ram

STATUS: Accepted

Currently accepted and proven technology used by the construction and demolition industries for size reduction of concrete structures. Application is directly related to the remediation of problems similar to the identified site specific work tasks.

These hydraulic powered rams replace the old conventional jackhammer in all most all operational sites due to the variable sizes and accessibility by equipment and rams to work site. Only a very few select work sites are strictly accessible to manual labor and jackhammers (the smaller skid/steer loaders w/rams can get to most tight locations within a building or job site).

There are several manufacturers of hydraulic powered rams which are commercially available and technically proven. All of these hydraulic powered rams are operated through a hydraulic piston

drive system which are supplied by the supporting equipment (typically a backhoe or front end loader).

SCIENCE TECHNOLOGY NEEDS:

No new scientific investigation and/or technological development is necessary to fully implement commercially available equipment, sized to meet the identified site specific work tasks.

These hydraulic powered rams have a wide range of equipment sizes to meet the desired performance characteristics required for the particular work task and site physical conditions. The particular ram size must also be matched to the support equipment size, e.g., an 1,000 lb. ram, utilized on the third member of a backhoe, would require a 20,000 lb. class backhoe, vs. an 6,500 lb. ram, utilized on the third member of a backhoe, would require a 130,000 lb. class backhoe, etc.

The hydraulic powered shears vary in sizes and types and can be matched to the project specific requirements. These sizes range from the smaller 105 lb. class, to the medium 2,100 lb. class, to the large 6,500 lb. class. These rams range in impact energy up to 9,000 ft. lbs.

IMPLEMENTATION NEEDS:

A water spray system for confinement of radioactive contaminated materials (concrete debris) would need to be developed. This could simply be a labor craft personnel with a water hose and spray wand (keep it simple).

COMMENTS:

The EG&G Idaho D&D Projects Unit currently is in the process of procuring a hydraulic ram impact hammer which it has been utilizing for the various demolition type operations at the INEL. The following are the equipment's major specifications for reference (more detailed specifications can be obtained upon request):

Attachment Weight:	Approximately 1,700 lbs.
Impact Energy:	1,500 ft./lb.
Blows per minute:	500-700
Mounting:	Must be readily mountable to CASE 688 Crawler Excavator (quick connect type attachments).

EVALUATOR: Donald J. Kenoyer Phone (208) 526-9837
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REFERENCES:

There are many manufacturers of hydraulic powered shears and concrete pulverizers within the United States, including foreign Americanized companies. The "Buy American" philosophy should not bias the engineering decisions on the best equipment available.

The following is a listing of the major manufacturers of hydraulic powered rams, and does not attempt to be a complete listing.

ATTACHMENT EQUIPMENT MANUFACTURER

JRB Company, Inc.
P.O. Box 9445
Akron, OH 44305
Phone: (216) 733-6800

LaBounty Manufacturing Div.
100 State Road Two
Two Harbors, MN 55616
Phone: (218) 834-2123

Link-Belt Constr. Equip. Co.
2651 Palumbo Drive
Lexington, KY 40509
Phone: (606) 263-5200

Stanley Hydraulic Tools
3810 SE Naef Road
Milwaukie, OR 97267
Phone: (503) 659-5660

Tramac Corporation
7 Emery Avenue
Rudolph, NJ 07869
Phone: (201) 361-0490

LOCAL DISTRIBUTOR

Armond Machinery Co.
3330 N. Yellowstone Hwy.
Idaho Falls, ID
Phone: (208) 523-0822

Armond Machinery Co.
P.O. Box 30020
Salt Lake City, UT 84130
Phone: (801) 972-4000

Central Equipment Co.
2700 1/2 S. 5th Ave.
Pocatello, ID
Phone: (208) 233-2850

Case Power & Equipment
5666 N. Yellowstone Hwy.
Idaho Falls, ID. 83401
Phone: (208) 523-5455

Arnold Machinery Co.
3330 N. Yellowstone Hwy.
Idaho Falls, ID
Phone: (208) 523-0822

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.
OU 2-05, TRA-15.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 1-03, TSF-38; OU 4-05, CFA-17.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.
OU 7-08,R1/FS

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; Hazardous-organics.

Waste Form/Contaminants:

Concrete; Soil; Debris-glass, plastic; Sludge/⁵⁴Mn ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag, any metal or laboratory chemical, and fuel oil spills.

SUBELEMENTS: Retrieval

ALTERNATIVES: Manual vapor vacuum

TECHNOLOGY: Manual vapor vacuum/pump

STATUS: Accepted

Primarily utilized to remove vapors from tanks. Alternate systems would include liquid extraction pumping and collection systems for the removal of tank liquids and sludge. These are commercially available and/or can be specifically designed for the work task.

SCIENCE AND TECHNOLOGY NEEDS:

ER&WM D&D Projects Unit Underground Storage Tanks (UST) group utilized a heating and pumping extraction/collection system. SPERT IV Hot Waste Tanks due to be completed this FY-1993, utilized such a system.

IMPLEMENTATION NEEDS:

Site specific.

COMMENTS:

None.

EVALUATOR: Donald J. Kenoyer

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REFERENCES:

None provided. For more information, contact the above evaluator.

3. BIOLOGICAL AND CHEMICAL TREATMENT

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, tsf-06

Radioactive sumps, pits, ponds, trenches, and rubble piles

OU 1-05, TSF-21

PROBLEM AREA/CONTAMINANTS:

Waste Type:

Low-level radioactive-noncompactible

Waste Form/Contaminants:

Soil/¹³⁷Cs, ⁶⁰Co, ⁹⁰Sr

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Chemical washing (cobalt, cesium, and strontium)

Process: 1) DC-18-C-6 and dinonylnaptalene sulfonic acid in n-dodecane and tert-butyl-B-21-C-7.
2) Amalgam electrowinning.
3) Ion exchange.

These methods involve excavating the soil, concrete, or metal, leaching the ground concrete and/or soil with water, subsequent acid washes may be necessary. Any contaminated metal should be washed with HNO₃. The washing step should be followed with the introduction of organic phase solubilized crown ethers which will give two separate phases aqueous and organic. The aqueous phase will require further cycling for removal of the residual metals. The organic phase will be contaminated with the majority of the metals. This phase will require further processing before it can be either recycled or incinerated. Two alternative technologies subsequent to the washing is, to use amalgam electrowinning or ion exchange.

STATUS: Research and development needed

This is a developing technology that can be applied, but is currently very costly. The technologies to be used are generally very inefficient. Crown ethers are currently available only in small quantities. Usually the research facilities that are working with these crown ethers make the small amounts of the particular crown ether that is required. Amalgam electrowinning is not commercially available. This technology is being developed at the INEL.

SCIENCE AND TECHNOLOGY NEEDS:

Process development is needed to improve efficiency and increase the extent of contaminant removal which can be achieved.

Development of amalgam electrowinning will be required. As stated before this technology is not available commercially.

IMPLEMENTATION NEEDS:

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the soil and cement and determine how many times the system should be repeated per amount of contamination. Research and development of mass production of the crown ethers will be required to produce larger quantities than are currently being produced. Process equipment for field work and scale up will also be required.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined.

Chemical Washing: A broad technological area where an unlimited number of process steps and chemical solutions are used to remove contaminants from a surface by cleaning or leaching and solubilizing them in a solvent. The application of specific technologies vary in maturity from very old and mature technologies used in the mining industry to conceptual methods for the removal of radionuclides from contaminated soils.

Crown Ether Extraction: In this document, crown ethers refer to those specific cyclic ethers and also, to similar compounds containing other heteroatoms. Crown ethers are cyclic organic compounds that have a hole in their mid section, much like that of a donut. The ether can be synthesized with a hole having specific dimensions (with limits), and lined with oxygen or other heteroatoms that have a binding affinity for certain metals. The technology involves exposing the contaminated solid or liquid to a solution containing specific ethers and an organic solvent. The metals of interest are captured by the ether and become solvated in the organic phase; which is further processed.

Ion Exchange: A broad technology area which is based on the use of resins containing chemical functionalities which have an affinity for ions. In this document, ion exchange refers to those technologies specifically targeting the extraction of cations (metals) from aqueous solutions.

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FAX (208) 526-8541

REFERENCES:

For further information, refer to *New Separation Chemistry Techniques for Radioactive Waste and Other Specific Applications*, edited by L. Cecille, M. Casarci and L. Pietrelli.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.
OU 3-07, CPP-26

PROBLEM AREA/CONTAMINANTS:

Waste Type:

Low-level radioactive-noncompactible

Waste Form/Contaminants:

Soil/⁹⁰Sr, ¹³⁷Cs, low levels of Pu

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Chemical washing (cesium, strontium, and plutonium)

Process: DC-18-C-6 and dinonylnaptalene sulfonic acid in n-dodecane and tert-butyl-B-21-C-7).
2) Amalgam electrowinning. 3) Ion exchange.

These methods involve excavating the soil, concrete, or metal, leaching the ground concrete and/or soil with water, subsequent acid washes may be necessary. Any contaminated metal should be washed with HNO₃. The washing step should be followed with the introduction of organic phase solubilized crown ethers which will give two separate phases aqueous and organic. The aqueous phase will require further cycling for removal of the residual metals. The organic phase will be contaminated, with the majority of the metals. This phase will require further processing before it can be either recycled or incinerated.

Two alternative technologies subsequent to the washing is, to use amalgam electrowinning or ion exchange.

STATUS: Research and development needed

This is a developing technology that can be applied, but is currently very costly. The technologies to be used are generally very inefficient. Crown ethers are currently available only in small quantities. Usually the research facilities that are working with these crown ethers make the small amounts of the particular crown ether that is required. Amalgam electrowinning is not commercially available. This technology is being developed at the INEL.

SCIENCE AND TECHNOLOGY NEEDS:

Process development is needed to improve efficiency and increase the extent of contaminant removal which can be achieved.

Development of amalgam electrowinning will be required. As stated before this technology is not available commercially.

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the soil and cement and determine how many times the system should be repeated per amount of contamination. Research and development of mass production of the crown ethers will be required to produce larger quantities than are currently being produced. Process equipment for field work and scale up will also be required.

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined.

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Ion Exchange: A broad technology area which is based on the use of resins containing chemical functionalities which have an affinity for ions. In this document, ion exchange refers to those technologies specifically targeting the extraction of cations (metals) from aqueous solutions.

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For further information, refer to *New Separation Chemistry Techniques for Radioactive Waste and Other Specific Applications*, edited by L. Cecille, M. Casarci and L. Pietrelli. Page 73.

INEL PROBLEM SITES:

Non radioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 2-07, TRA-36, TRA-39.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Hazardous - metals.

Waste Form/Contaminants:

Concrete, soil, wood/chromium, trivalent chromium.

SUBELEMENT: Biological and chemical treatment

ALTERNATIVE: Ex situ chemical treatment

TECHNOLOGY: Chemical washing (chromium)

This method of remediation involves excavating the soil and cement and grinding. The sludge should then be washed with dilute hydrochloric and/or hydrofluoric acid (HF_1 and/or HF). The acid may require recycling. The acid wash will result in two phases, aqueous and solid. The liquid phase should contain the chromium. Next, in a slightly basic environment, ferrous sulfide should be added to reduce the Cr^{+6} to Cr^{+3} . This should be complexed with hydroxide (OH) which will give $\text{Cr}(\text{OH})^3$. The solid should then be returned to its original place.

STATUS: Research and Development

This technology will require development. The techniques are cited in various chemistry books and are proven to work, but have not been proven to work on this type of application.

SCIENCE/TECHNOLOGY NEEDS:

Process development is needed to demonstrate the effectiveness of these methods on the application that the INEL site requires. This demonstration phase should allow for improvement of efficiency and optimization of the amount of contamination removed.

IMPLEMENTATION NEEDS:

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the sludge and determine how many times the system should be cycled per amount of contamination. Process equipment for field work and scale up will also be required.

COMMENTS:

Regulatory issues determining acceptable clean-up levels will need to be determined.

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REFERENCES:

For more information on the chelating agents and processes refer to *Chelates in Analytical Chemistry*, Volume 1, edited by H.A. Flaschka and A.J. Barnard, Jr.

INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 4-05, CFA-04

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.
OU 1-06, TST-08

PROBLEM AREA/CONTAMINANTS:

Waste Type:

Hazardous - metals

Waste Form/Contaminants:

Soil/Mercury

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Chemical washing (mercury)

This method of remediation involves excavating the soil. The solid should then be washed with dilute nitric (HNO_3), the nitric acid wash may require cycling. The acid wash result in two phases, aqueous and solid. The liquid phase should contain the mercury. This should be complexed with ferrous and sulfide (S^2 , Fe^{+2}) which will give HgS . The soil should then be returned to its original place.

STATUS: Research and development needed

This technology will require development. The techniques are cited in various chemistry books and are proven to work, but have not been proven to work on this type of application.

SCIENCE AND TECHNOLOGY NEEDS:

Process development is needed to demonstrate the effectiveness of these methods on the application that the INEL site requires. This demonstration phase should allow for improvement of efficiency and optimization of the amount of contamination removed.

IMPLEMENTATION NEEDS:

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the soil and determine how many times the system should be cycled per amount of contamination. Process equipment for field work and scale up will also be required.

COMMENTS:

Regulatory issues determining acceptable clean-up levels will need to be determined.

Chemical Washing: A broad technological area where an unlimited number of process steps and chemical solutions are used to remove contaminants from a surface by cleaning or leaching and solubilizing them in a solvent. The application of specific technologies vary in maturity from very old and mature technologies used in the mining industry to conceptual methods for the removal of radionuclides from contaminated soils.

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REFERENCES:

For more information on the chelating agents and processes, refer to *Chelates in Analytical Chemistry*, Volume 1, edited by H.A. Flaschka and A.J. Barnard, Jr.

INEL PROBLEM SITES:

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 5-12, PBF-08

PROBLEM AREA/CONTAMINANTS:

Waste Type:

Low-level radioactive - noncompactible

Waste Form/Contaminants:

Sludge/¹³⁷Cs, ⁶⁰Co

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Chemical washing (cobalt and cesium)

Process: 1) Dinonylnaptalene sulfonic acid in n-dodecane and tert-butyl-B-21-C-7). 2) Amalgam electrowinning. 3) Ion exchange.

These methods involve excavating the soil, concrete, or metal, leaching the ground concrete and/or soil with water, subsequent acid washes may be necessary. Any contaminated metal should be washed with HNO³. The washing step should be followed with the introduction of organic phase solubilized crown ethers which will give two separate phases aqueous and organic. The aqueous phase will require further cycling for removal of the residual metals. The organic phase will be contaminated, with the majority of the metals. This phase will require further processing before it can be either recycled or incinerated.

Two alternative technologies subsequent to the washing, is to use amalgam electrowinning or ion exchange.

STATUS: Research and development needed

This is a developing technology that can be applied, but is currently very costly. The technologies to be used are generally very inefficient. Crown ethers are currently available only in small quantities. Usually the research facilities that are working with these crown ethers make the small amounts of the particular crown ether that is required. Amalgam electrowinning is not commercially available. This technology is being developed at the INEL.

SCIENCE AND TECHNOLOGY NEEDS:

Process development is needed to improve efficiency and increase the extent of contaminant removal which can be achieved.

Development of amalgam electrowinning will be required. As stated before this technology is not available commercially.

IMPLEMENTATION NEEDS:

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the soil and cement and determine how many times the system should be repeated per amount of contamination. Research and development of mass production of the crown ethers will be required to produce larger quantities than are currently being produced. Process equipment for field work and scale up, will also be required.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined.

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Crown Ether Extraction: In this document, crown ethers refer to those specific cyclic ethers and also, to similar compounds containing other heteroatoms. Crown ethers are cyclic organic compounds that have a hole in their mid section, much like that of a donut. The ether can be synthesized with a hold having specific dimensions (with limits), and lined with oxygen or other heteroatoms that have a binding affinity for certain metals. The technology involves exposing the contaminated solid or liquid to a solution containing specific ethers and an organic solvent. The metals of interest are captured by the ether and become solvated in the organic phase; which is further processed.

Ion Exchange: A broad technology area which is based on the use of resins containing chemical functionalities which have an affinity for ions. In this document, ion exchange refers to those technologies specifically targeting the extraction of cations (metals) from aqueous solutions.

Amalgam Electrowinning: A developing electrochemical technology which uses mercury electrodes to reduce metal ions to the metallic state, whereupon, they are solvated (amalgamated) and removed from solution. The mercury electrode is regenerable and applicable to most metals and many radionuclides. Very high levels of metal removal are achievable.

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FAX (208) 526-8541

REFERENCES:

For further information, refer to *New Separation Chemistry Techniques for Radioactive Waste and Other Specific Applications*, edited by L. Cecille, M. Casarci and L. Pietrelli.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.
OU 3-09, CPP-69

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 3-09, CPP-01, CPP-02, CPP-06, CPP-09

Radioactive spill areas, spill migrations, and unconfined disposal sites.
OU 3-09, CPP-08, CPP-11, CPP-17, CPP-19, CPP-22; OU 3-11, CPP-58

PROBLEM AREA/CONTAMINANTS:**Waste Type:**

Low-level radioactive - liquid, noncompactible

Waste Form/Contaminants:

Liquid; Soil; Concrete; Floor, soil and asphalt/¹³⁷Cs, ¹³⁴Cs, ¹³⁷Cs and ¹³⁴Cs at 2R/hr., ¹³⁷Cs and ¹³⁴Cs at 200mR/hr.

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Chemical washing (cesium)

Process: 1) Tert-butyl-B-21-C7. 2) Amalgam electrowinning. 3) Ion exchange.

These methods involve excavating the soil, concrete, or metal, leaching the ground concrete and/or soil with water, subsequent acid washes may be necessary. Any contaminated metal should be washed with HNO₃. The washing step should be followed with the introduction of organic phase solubilized crown ethers which will give two separate phases aqueous and organic. The aqueous phase will require further cycling for removal of the residual metals. The organic phase will be contaminated, with the majority of the metals. This phase will require further processing before it can be either recycled or incinerated. Two alternative technologies, subsequent to the washing, are to use amalgam electrowinning or ion exchange.

STATUS: Research and development needed

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Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the soil and cement and determine how many times the system should be repeated per amount of contamination. Research and development of mass production of the crown ethers will be required to produce larger quantities than are currently being produced. Process equipment for field work and scale up will also be required.

COMMENTS:

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REFERENCES:

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INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 3-07, CPP-28, CPP-79

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 3-09, CPP-04, CPP-05

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-35; OU 3-09, CPP-03; OU 3-12, CPP-80

PROBLEM AREA/CONTAMINANTS:

Waste Type:

Low-level radioactive - noncompactible

Waste Form/Contaminants:

Concrete; Soil/ ^{90}Sr , ^{137}Cs

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Chemical washing (cesium and strontium)

Process: 1) DC-18-C-6 and dinonylnaptalene sulfonic acid in n-dodecane and tert-butyl-B-21-C-7). 2) Amalgam electrowinning. 3) Ion exchange.

These methods involve excavating the soil, concrete, or metal, leaching the ground concrete and/or soil with water, subsequent acid washes may be necessary. Any contaminated metal should be washed with HNO_3 . The washing step should be followed with the introduction of organic phase solubilized crown ethers which will give two separate phases aqueous and organic. The aqueous phase will require further cycling for removal of the residual metals. The organic phase will be contaminated, with the majority of the metals. This phase will require further processing before it can be either recycled or incinerated.

Two alternative technologies, subsequent to the washing, are to use amalgam electrowinning or ion exchange.

STATUS: Research and development needed

This is a developing technology that can be applied, but is currently very costly. The technologies to be used are generally very inefficient. Crown ethers are currently available only in small quantities. Usually the research facilities that are working with these crown ethers make the small amounts of the particular crown ether that is required. Amalgam electrowinning is not commercially available. This technology is being developed at the INEL.

SCIENCE AND TECHNOLOGY NEEDS:

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Development of amalgam electrowinning will be required. As stated before this technology is not available commercially.

IMPLEMENTATION NEEDS:

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the soil and cement and determine how many times the system should be repeated per amount of contamination. Research and development of mass production of the crown ethers will be required to produce larger quantities than are currently being produced. Process equipment for field work and scale up will also be required.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined.

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REFERENCES:

For further information, refer to *New Separation Chemistry Techniques for Radioactive Waste and Other Specific Applications*, edited by L. Cecille, M. Casarci and L. Pietrelli.

INEL PROBLEM SITES:

Landfills.

OU 4-12, CFA-02, CFA-03

PROBLEM AREA/CONTAMINANTS:

Waste Type:

Municipal - sanitary

Waste Form/Contaminants:

Sludge/chromium, mercury, beryllium, trichloroethane

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Chemical washing (chromium, mercury, and beryllium)

This method of remediation involves excavating the sludge. The sludge should then be washed with dilute nitric (HNO_3), the nitric acid wash may require cycling. The acid wash result in two phases, aqueous and solid. The liquid phase should contain the chromium and mercury. This should be complexed with ferrous, sulfide and hydroxide (S^{2-} , OH^- , Fe^{+2}) which will give HgS , $\text{Cr}(\text{OH})_3$. The sludge, or solid phase, which will contain the beryllium (Be^{+2} , Be^0) should be complexed with the use of acetylacetone, then the $\text{Be}^{+2}(\text{acac})$ which is very volatile should be placed in an air fluidized bed. The solid should then be returned to its original place.

STATUS: Research and development needed

This technology will require development. The techniques are cited in various chemistry books and are proven to work, but have not been proven to work on this type of application.

SCIENCE AND TECHNOLOGY NEEDS:

Process development is needed to demonstrate the effectiveness of these methods on the application that the INEL site requires. This demonstration phase should allow for improvement of efficiency and optimization of the amount of contamination removed.

IMPLEMENTATION NEEDS:

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the sludge and determine how many times the system should be cycled per amount of contamination. Process equipment for field work and scale up will also be required.

COMMENTS:

Regulatory issues determining acceptable clean-up levels will need to be determined.

Chemical Washing: A broad technological area where an unlimited number of process steps and chemical solutions are used to remove contaminants from a surface by cleaning or leaching and solubilizing them in a solvent. The application of specific technologies vary in maturity from very old and mature technologies used in the mining industry to conceptual methods for the removal of radionuclides from contaminated soils.

EVALUATOR: Stuart K. Janikowski Phone (208) 526-0265
FAX (208) 526-8541

REFERENCES:

For more information on the chelating agents and processes refer to *Chelates in Analytical Chemistry*, Volume 1, edited by H.A. Flaschka and A.J. Barnard, Jr.

INEL PROBLEM SITES:

Landfills.

OU 4-12, CFA-02

PROBLEM AREA/CONTAMINANTS:

Waste Type:

Municipal - sanitary

Waste Form/Contaminants:

Solid/Chromium, mercury, beryllium, trichloroethane

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Chemical washing (chromium, mercury, and beryllium)

This method of remediation involves excavating the soil. The solid should then be washed with dilute nitric (HNO_3), the nitric acid wash may require cycling. The acid wash result in two phases, aqueous and solid. The liquid phase should contain the chromium and mercury. This should be complexed with ferrous, sulfide and hydroxide (S^{2-} , OH^- , Fe^{+2}) which will give HgS , $\text{Cr}(\text{OH})^3$. The soil, or solid phase, which will contain the beryllium (Be^{+2} , Be^0) should be complexed with the use of acetylacetone, then the $\text{Be}^{+2}(\text{acac})$ which is very volatile should be placed in an air fluidized bed. The soil should then be returned to its original place.

STATUS: Research and development needed

This technology will require development. The techniques are cited in various chemistry books and are proven to work, but have not been proven to work on this type of application.

SCIENCE AND TECHNOLOGY NEEDS:

Process development is needed to demonstrate the effectiveness of these methods on the application that the INEL site requires. This demonstration phase should allow for improvement of efficiency and optimization of the amount of contamination removed.

IMPLEMENTATION NEEDS:

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the soil and determine how many times the system should be cycled per amount of contamination. Process equipment for field work and scale up will also be required.

COMMENTS:

Chemical Washing: A broad technological area where an unlimited number of process steps and chemical solutions are used to remove contaminants from a surface by cleaning or leaching and

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3 of 4

INEL PROBLEM SITES:

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 1-06, LOFT-01; OU 4-09, CFA-26

PROBLEM AREA/CONTAMINANTS:

Waste Type:

Petroleum

Waste Form/Contaminants:

Soil/No. 2 diesel fuel, diesel fuel

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Chemical washing - organics

These methods involve excavating the soil, concrete, or sludge, washing the ground concrete and/or soil, and sludge with a surfactant, subsequent washes may be necessary. The washing step should be followed with the introduction of biodegradation technologies. This phase will require further processing before it can be either recycled or incinerated.

STATUS: Research and development needed

This is a developed technology that can be applied, but is currently very costly. Research may be required to optimize the biodegradation process.

SCIENCE AND TECHNOLOGY NEEDS:

Process development is needed to improve efficiency and increase the extent of contaminant removal which can be achieved.

IMPLEMENTATION NEEDS:

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the soil and cement and determine how many times the system should be repeated per amount of contamination. Process equipment for field work and scale up will also be required.

COMMENTS:

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EVALUATOR: Stuart K. Janikowski Phone (208) 526-0265
FAX (208) 526-8541

REFERENCES:

None provided. For additional information, contact the above evaluator.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.
OU 2-05, TRA-15

PROBLEM AREA/CONTAMINANTS:**Waste Type:**

Mixed low-level radioactive

Waste Form/Contaminants:

Laboratory waste-liquid/Silver, mercury, radioisotopes, ^{54}Mn , ^{97}Nb , ^{60}Co , ^{134}Cs , ^{144}Cs , ^{137}Cs , ^{90}Sr , ^{154}Eu , ^{110}Ag

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Amalgam electrowinning

The liquid should first undergo amalgam electrowinning. The liquid should then be washed with an EDTA wash, subsequent washes may be necessary. This washing step should be followed with a salicylaldehyde wash. This may require several repetitions. The final step should be an ion exchange polishing.

STATUS: Research and development needed

This is a developing technology that can be applied, but is currently very costly. Research may be required to optimize the process. The amalgam electrowinning is a developing technology that is currently being researched at the INEL.

SCIENCE AND TECHNOLOGY NEEDS:

Process development is needed to improve efficiency and increase the extent of contaminant removal which can be achieved.

IMPLEMENTATION NEEDS:

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the soil and cement and determine how many times the system should be repeated per amount of contamination. Process equipment for field work and scale up will also be required.

COMMENTS:

Amalgam Electrowinning: A developing electrochemical technology which uses mercury electrodes to reduce metal ions to the metallic state, whereupon, they are solvated (amalgamated) and removed from solution. The mercury electrode is regenerable and applicable to most metals and many radionuclides. Very high levels of metal removal are achievable.

EVALUATOR: Stuart K. Janikowski Phone (208) 526-0265
FAX (208) 526-8541

REFERENCES:

None provided. For additional information, contact the above evaluator.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.
OU 2-05, TRA-15

PROBLEM AREA/CONTAMINANTS:

Waste Type:

Low-level radioactive - noncompactible

Waste Form/Contaminants:

Concrete and soil/⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Nitric acid/EDTA wash

These methods involve excavating the soil, concrete, or sludge, washing the ground concrete and/or soil, and sludge with a nitric acid/EDTA wash, subsequent washes may be necessary. This washing step should be followed with an acac/salicylaldehyde wash, this may require several repetitions. Next a HCl/HF wash should be performed and repeated as necessary. The final wash should be a water wash to assure any residue is removed. The liquid should then undergo amalgam electrowinning, followed by ion exchange.

STATUS: Research and development needed

This is a developing technology that can be applied, but is currently very costly. Research may be required to optimize the process. The amalgam electrowinning is a developing technology that is currently being researched at the INEL.

SCIENCE AND TECHNOLOGY NEEDS:

Process development is needed to improve efficiency and increase the extent of contaminant removal which can be achieved.

IMPLEMENTATION NEEDS:

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the soil and cement and determine how many times the system should be repeated per amount of contamination. Process equipment for field work and scale up will also be required.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining cleanup levels will need to be defined.

Ion Exchange: A broad technology area which is based on the use of resins containing chemical functionalities which have an affinity for ions. In this document, ion exchange refers to those technologies specifically targeting the extraction of cations (metals) from aqueous solutions.

Amalgam Electrowinning: A developing electrochemical technology which uses mercury electrodes to reduce metal ions to the metallic state, whereupon, they are solvated (amalgamated) and removed from solution. The mercury electrode is regenerable and applicable to most metals and many radionuclides. Very high levels of metal removal are achievable.

EVALUATOR: Stuart K. Janikowski Phone (208) 526-0265
FAX (208) 526-8541

REFERENCES:

None provided. For additional information, contact the above evaluator.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 3-07, CPP-26, CPP-28, CPP-31; OU 3-08, CPP-27

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-04, LOFT-02

PROBLEM AREA/CONTAMINANTS:**Waste Type:**

Low-level radioactive - noncompactible; Mixed low-level radioactive - noncompactible, corrosive, metals; Hazardous - metals

Waste Form/Contaminants:

Soil; Concrete/90Sr, 137Cs, low levels of Pu, mercuric nitrate, nitric acid, lead, mercury

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Dilute nitric acid washing

This method involves excavating of the soil, concrete, or metal, leaching the ground concrete and/or soil with a dilute nitric acid wash. Subsequent acid washes may be necessary. This wash should be followed by amalgam electrowinning. The soil that remains after the acid wash and a water rinse should be returned to its original place. The liquid acid solution should be sent to PNL to their Acid Recovering Unit. Or, opt to obtain an acid recovering unit for our facility. The metals that are recovered from the amalgam electrowinning should be placed in cement and be discarded according to regulations.

STATUS: Research and development needed

Chemical washing has been an accepted method for several years. Amalgam electrowinning is not commercially available. This technology is being developed at the INEL.

SCIENCE AND TECHNOLOGY NEEDS:

Process development is needed to improve efficiency and increase the extent of contaminant removal which can be achieved.

Development of amalgam electrowinning will be required. As stated before this technology is not available commercially.

IMPLEMENTATION NEEDS:

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of

COMMENTS:

REFERENCES:

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INEL PROBLEM SITES:

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 3-13, CPP-48

PROBLEM AREA/CONTAMINANTS:**Waste Type:**

Hazardous - organics

Waste Form/Contaminants:

Concrete; Soil/ Nitric acid

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Sodium bicarbonate washing

These methods involve excavating the soil, concrete, or sludge, washing the ground concrete and/or soil, and sludge with a sodium bicarbonate solution. Subsequent washes may be necessary. The washing step should be followed with the introduction of either biodegradation and/or incineration technologies.

STATUS: Demonstration, testing, and evaluation needed

This is a developed technology that can be applied. Research may be required to optimize the process.

SCIENCE AND TECHNOLOGY NEEDS:

None identified.

IMPLEMENTATION NEEDS:

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the soil and cement and determine how many times the system should be repeated per amount of contamination. Process equipment for field work and scale up will also be required.

COMMENTS:

None.

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REFERENCES:

None provided. For additional information, contact the above evaluator.

INEL PROBLEM SITES:

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 4-09, CFA-42

PROBLEM AREA/CONTAMINANTS:

Waste Type:

Hazardous - organics

Waste Form/Contaminants:

Soil/Fuel oil

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Surfactant washing

These methods involve excavating the soil, concrete, or sludge, washing the ground concrete and/or soil, and sludge with a surfactant, subsequent washes may be necessary. The washing step should be followed with the introduction of biodegradation technologies. This phase will require further processing before it can be either recycled or incinerated.

STATUS: Research and development needed

This is a developing technology that can be applied, but is currently very costly. Research may be required to optimize the biodegradation process.

SCIENCE AND TECHNOLOGY NEEDS:

Process development is needed to improve efficiency and increase the extent of contaminant removal which can be achieved.

IMPLEMENTATION NEEDS:

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the soil and cement and determine how many times the system should be repeated per amount of contamination. Process equipment for field work and scale up will also be required.

COMMENTS:

Surfactant Washing: A form of chemical washing that specifically uses surfactants, rather than harsh solvents, for the removal of soilants and chemicals from solid or particulate surfaces. This is a developing technology that requires significant testing on the specific site prior to implementation.

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REFERENCES:

None provided. For additional information, contact the above evaluator.

INEL PROBLEM SITES:

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-06, TSF-07

PROBLEM AREA/CONTAMINANTS:

Waste Type:

Mixed low-level radioactive

Waste Form/Contaminants:

Soil/¹³⁷Cs, ⁶⁰Cs, Hg

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Chemical washing (cobalt, cesium, and mercury)

Process: 1) Dinonylnapthalene sulfonic acid in n-dodecane and tert-butyl-B-21-C-7. 2) Amalgam electrowinning. 3) Ion exchange.

These methods involve excavating the soil, concrete, or metal, leaching the ground concrete and/or soil with water, subsequent acid washes may be necessary. Nitric (HNO₃), the nitric acid wash may require cycling. The acid wash result in two phases, aqueous and solid. The liquid phase should contain the mercury. This should be complexed with ferrous and sulfide (S²⁻, Fe⁺²) which will give HgS. This step should be followed with the introduction of organic phase solubilized crown ethers which will give two separate phases aqueous and organic. The aqueous phase will require further cycling for removal of the residual metals. The organic phase will be contaminated, with the majority of the metals. This phase will require further processing before it can be either recycled or incinerated. Two alternative technologies, subsequent to the washing, are to use amalgam electrowinning or ion exchange. The soil should then be returned to its original place.

STATUS: Research and development needed

The techniques are cited in various chemistry books and are proven to work, but have not been proven to work on this type of application.

The crown ether process is a developing technology that can be applied, but is currently very costly. The technologies to be used are generally very inefficient. Crown ethers are currently available only in small quantities. Usually the research facilities that are working with these crown ethers make the small amounts of the particular crown ether that is required.

Amalgam electrowinning is not commercially available. This technology is being developed at the INEL.

SCIENCE AND TECHNOLOGY NEEDS:

Process development is needed to improve efficiency and increase the extent of contaminant removal which can be achieved.

Development of amalgam electrowinning will be required. As stated before this technology is not available commercially.

IMPLEMENTATION NEEDS:

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the soil and cement and determine how many times the system should be repeated per amount of contamination. Process equipment for field work and scale up, will also be required.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined.

Chemical Washing: A broad technological area where an unlimited number of process steps and chemical solutions are used to remove contaminants from a surface by cleaning or leaching and solubilizing them in a solvent. The application of specific technologies vary in maturity from very old and mature technologies used in the mining industry to conceptual methods for the removal of radionuclides from contaminated soils.

Crown Ether Extraction: In this document, crown ethers refer to those specific cyclic ethers and also, to similar compounds containing other heteroatoms. Crown ethers are cyclic organic compounds that have a hole in their mid section, much like that of a donut. The ether can be synthesized with a hole having specific dimensions (with limits), and lined with oxygen or other heteroatoms that have a binding affinity for certain metals. The technology involves exposing the contaminated solid or liquid to a solution containing specific ethers and an organic solvent. The metals of interest are captured by the ether and become solvated in the organic phase; which is further processed.

Ion Exchange: A broad technology area which is based on the use of resins containing chemical functionalities which have an affinity for ions. In this document, ion exchange refers to those technologies specifically targeting the extraction of cations (metals) from aqueous solutions.

Amalgam Electrowinning: A developing electrochemical technology which uses mercury electrodes to reduce metal ions to the metallic state, whereupon, they are solvated (amalgamated) and removed from solution. The mercury electrode is regenerable and applicable to most metals and many radionuclides. Very high levels of metal removal are achievable.

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REFERENCES:

For further information refer to *New Separation Chemistry Techniques for Radioactive Waste and Other Specific Applications*, edited by L. Cecille, M. Casarci and L. Pietrelli.

For more information on the chelating agents and processes refer to *Chelates in Analytical Chemistry*, Volume 1, edited by H. A. Flaschka and A. J. Barnard, Jr.

CHEMICAL WASHING (COBALT, CESIUM, CHROMIUM AND MERCURY) BICH-026

INEL PROBLEM SITES:

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 5-12, PBF-10

PROBLEM AREA/CONTAMINANTS:

Waste Type:

Mixed low-level radioactive - metals

Waste Form/Contaminants:

Soil/⁶⁰Co, ¹³⁷Cs, chromium

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Chemical washing (cobalt, cesium, chromium, and mercury)

Process: 1) Dinonylnaptalene sulfonic acid in n-dodecane and tert-butyl-B-21-C-7. 2) Amalgam electrowinning. 3) Ion exchange.

These methods involve excavating the soil, concrete, or metal, leaching the ground concrete and/or soil with dilute hydrochloric and/or hydrofluoric acid (HCl and/or HF), the acid wash may require cycling. The next step should be in a slightly basic environment ferrous sulfide should be added to reduce the Cr⁺⁶ to Cr⁺³. This should be complexed with hydroxide (OH) which will give Cr(OH)₃. This should be followed with the introduction of organic phase solubilized crown ethers which will give two separate phases aqueous and organic. The aqueous phase will require further cycling for removal of the residual metals. This will be contaminated, with the majority of the metals. This phase will require further processing before it can be either recycled or incinerated. Two alternative technologies, subsequent to the washing, are to use amalgam electrowinning or ion exchange.

STATUS: Research and development needed

This is a developing technology that can be applied, but is currently very costly. The technologies to be used are generally very inefficient. Crown ethers are currently available only in small quantities. Usually the research facilities that are working with these crown ethers make the small amounts of the particular crown ether that is required. Amalgam electrowinning is not commercially available. This technology is being developed at the INEL.

SCIENCE AND TECHNOLOGY NEEDS:

Process development is needed to improve efficiency and increase the extent of contaminant removal which can be achieved.

Development of amalgam electrowinning will be required. As stated before this technology is not available commercially.

INEL PROBLEM SITES:

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 4-09, CFA-10

PROBLEM AREA/CONTAMINANTS:

Waste Type:

Hazardous - organics

Waste Form/Contaminants:

Soil and gravel/PCB spill

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Chemical wash - PCBs

Process: 1) Surfactant soil wash. 2) Catalytic PCB destruction.

These methods involve excavating the soil or gravel washing the soil or gravel with a surfactant. Subsequent washes may be necessary. The washings should then be dealt with by use of low temperature catalytic destruction of PCB.

STATUS: Demonstration, testing and evaluation needed

This is a developed technology that can be applied, and is currently being used.

SCIENCE AND TECHNOLOGY NEEDS:

Process development may be needed to improve efficiency and increase the extent of contaminant removal which can be achieved.

IMPLEMENTATION NEEDS: Low implementation costs

COMMENTS:

Chemical Washing: A broad technological area where an unlimited number of process steps and chemical solutions are used to remove contaminants from a surface by cleaning or leaching and solubilizing them in a solvent. The application of specific technologies vary in maturity from very old and mature technologies used in the mining industry to conceptual methods for the removal of radionuclides from contaminated soils.

EVALUATOR: Stuart K. Janikowski Phone (208) 526-0265
FAX (208) 526-8541

REFERENCES:

None provided. For additional information, contact the above evaluator.

INEL PROBLEM SITES:

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 7-13, RWMC-04

PROBLEM AREA/CONTAMINANTS:

Waste Type:

Radioactive, mixed radioactive, hazardous - organic, transuranic, Rocky Flats fire waste, Pu, fuel end boxes

Waste Form/Contaminants:

Soil; Debris-paper, rags, sweepings, vehicles, diatomaceous earth, wood, metal, glass/⁶⁰Co, TCE, toluene, carbon tetrachloride, Pu

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Hot nitrogen stripping

Process: DC-18-C-6 and dinonylnaptalene sulfonic acid in n-dodecane and tert-butyl-B-21-C-7.

These methods involve excavating the soil, concrete, or metal, hot nitrogen stripping then leaching the ground concrete and/or soil with nitric acid. Subsequent washes may be necessary. The washing step should be followed with the introduction of organic phase solubilized crown ethers which will give two separate phases aqueous and organic. The aqueous phase will require further cycling for removal of the residual metals. The organic phase will be contaminated, with the majority of the metals. This phase will require further processing which should include reduction of the Pu with Fe(II) sulfate then precipitation with the addition of oxalic acid. Two alternative technologies subsequent to the washing, is to use amalgam electrowinning or ion exchange.

STATUS: Research and development needed

This is a developing technology that can be applied, but is currently very costly. The technologies to be used are documented to be successful in various text books, but have not been used for the purpose of waste reduction. The technologies to be used are generally very inefficient. Crown ethers are currently available only in small quantities. Usually the research facilities that are working with these crown ethers make the small amounts of the particular crown ether that is required.

Amalgam electrowinning is not commercially available. This technology is being developed at the INEL.

SCIENCE AND TECHNOLOGY NEEDS:

Process development may be required to improve efficiency and increase the extent of contaminant removal which can be achieved.

Development of amalgam electrowinning will be required. As stated before this technology is not available commercially.

IMPLEMENTATION NEEDS:

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the soil and cement and determine how many times the system should be repeated per amount of contamination. Research and development of mass production of the crown ethers will be required to produce larger quantities than are currently being produced. Process equipment for field work and scale up will also be required.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined.

Hot Nitrogen Stripping: A technology developed by the mN Company for recovering fine organic chemicals from carbon absorption filters. Hot, dry nitrogen gas is passed over the contaminated material and solubilizes the volatile components. The contaminants are removed from the gas stream and the nitrogen is recycled. This technology is immature in other applications.

Amalgam Electrowinning: A developing electrochemical technology which uses mercury electrodes to reduce metal ions to the metallic state, whereupon, they are solvated (amalgamated) and removed from solution. The mercury electrode is regenerable and applicable to most metals and many radionuclides. Very high levels of metal removal are achievable.

Ion Exchange: A broad technology area which is based on the use of resins containing chemical functionalities which have an affinity for ions. In this document, ion exchange refers to those technologies specifically targeting the extraction of cations (metals) from aqueous solutions.

EVALUATOR: Stuart K. Janikowski Phone (208) 526-0265
FAX (208) 526-8541

REFERENCES:

For further information refer to *New Separation Chemistry Techniques for Radioactive Waste and Other Specific Applications*, edited by L. Cecille, M. Casarci and L. Pietrelli.

INEL PROBLEM SITES:

Radioactive spill areas, spill migrations, and unconfined disposal sites.
OU 3-08, CPP-13

PROBLEM AREAS/CONTAMINANTS:

Waste Type:

Low-level radioactive - noncompactible

Waste Form/Contaminants:

Concrete; Soil/⁹⁰Sr, ¹³⁷Cs, ^{ru}g

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Cold dilute potassium hydroxide washing

Process: DC-18-C-6 and dinonylnaptalene sulfonic acid in n-dodecane and tert-butyl-B-21-C-7.

These methods involve excavating the soil, concrete, or metal, leaching the ground concrete and/or soil with dilute KOH. Subsequent acid washes may be necessary. The washing step should be followed with the introduction of organic phase solubilized crown ethers which will give two separate phases aqueous and organic. The aqueous phase will require further cycling for removal of the residual metals. The organic phase will be contaminated, with the majority of the metals. This phase will require further processing before it can be either recycled or incinerated. After the cold KOH wash, which may require cycling the acid solution should be sent to amalgam electrowinning then to an ion exchange.

STATUS: Research and development needed

This is a developing technology that can be applied, but is currently very costly. The technologies to be used are generally very inefficient. Crown ethers are currently available only in small quantities. Usually the research facilities that are working with these crown ethers make the small amounts of the particular crown ether that is required. Amalgam electrowinning is not commercially available. This technology is being developed at the INEL.

SCIENCE AND TECHNOLOGY NEEDS:

Process development may be required to improve efficiency and increase the extent of contaminant removal which can be achieved.

Development of amalgam electrowinning will be required. As stated before this technology is not available commercially.

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the soil and cement and determine how many times the system should be repeated per amount of contamination. Research and development of mass production of the crown ethers will be required to produce larger quantities than are currently being produced. Process equipment for field work and scale up will also be required.

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be determined.

REFERENCES:

For further information refer to *New Separation Chemistry Techniques for Radioactive Waste and Other Specific Applications*, edited by L. Cecille, M. Casarci and L. Pietrelli.

INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-03, WRRTF-01

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 4-06, CFA-44

PROBLEM AREAS/CONTAMINANTS:

Waste Type:

Hazardous - metals, organics

Waste Form/Contaminants:

Soil/Heavy hydrocarbons, Pb, lead and paint thinner

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Surfactant wash/dilute nitric acid washing

These methods involve excavating the soil, washing the soil with surfactant wash to remove the hydrocarbons and paint thinner. The soil should then be washed with a dilute nitric acid wash. Subsequent acid washes may be necessary. The soil that remains after the acid wash and a water rinse should be returned to its original place. This wash could be processed in several ways: 1) Amalgam electrowinning, 2) S^{2-} precipitation, 3) ion exchange, or 4) chemical reduction followed by retort. The liquid acid solution should be sent to PNL to their Acid Recovering Unit. Or, opt to obtain an acid recovering unit for our facility.

STATUS: Research and development needed

Chemical washing has been an accepted method for several years. Amalgam electrowinning is not commercially available. This technology is being developed at the INEL. The technologies mentioned here have not been used in this capacity before, therefore, there will be some process modifications required.

SCIENCE AND TECHNOLOGY NEEDS:

Process development is needed to improve efficiency and increase the extent of contaminant removal which can be achieved. Development of amalgam electrowinning will be required. As stated before this technology is not available commercially.

IMPLEMENTATION NEEDS:

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of

the soil and cement and determine how many times the system should be repeated per amount of contamination. Process equipment for field work and scale up, will also be required.

COMMENTS:

Ion Exchange: A broad technology area which is based on the use of resins containing chemical functionalities which have an affinity for ions. In this document, ion exchange refers to those technologies specifically targeting the extraction of cations (metals) from aqueous solutions.

Amalgam Electrowinning: A developing electrochemical technology which uses mercury electrodes to reduce metal ions to the metallic state, whereupon, they are solvated (amalgamated) and removed from solution. The mercury electrode is regenerable and applicable to most metals and many radionuclides. Very high levels of metal removal are achievable.

Surfactant Washing: A form of chemical washing that specifically uses surfactants, rather than harsh solvents, for the removal of soilants and chemicals from solid or particulate surfaces. This is a developing technology that requires significant testing on the specific site prior to implementation.

EVALUATOR: Stuart K. Janikowski Phone (208) 526-0265
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REFERENCES:

None provided. For additional information, contact the above evaluator.

INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 4-06, CFA-06

PROBLEM AREAS/CONTAMINANTS:

Waste Type:
Hazardous - metals

Waste Form/Contaminants:

Soil and lead chunks/lead and lead oxide

SUBELEMENTS: Biological and chemical treatment

ALTERNATIVES: Ex situ chemical treatment

TECHNOLOGY: Dilute nitric acid wash - lead

These methods involve excavating and separating the lead chunks. The lead chunks should be sent to a smelter. The soil should be leached with a dilute nitric acid wash. Subsequent acid washes may be necessary. The soil that remains after the acid wash and a water rinse should be returned to its original place. This wash could be processed in several ways: 1) Amalgam electrowinning, 2) S^{2-} precipitation, 3) ion exchange, or 4) chemical reduction followed by retort. The liquid acid solution should be sent to PNL to their Acid Recovering Unit. Or, opt to obtain an acid recovering unit for our facility.

STATUS: Research and development needed

Chemical washing has been an accepted method for several years. Amalgam electrowinning is not commercially available. This technology is being developed at the INEL. The technologies mentioned here have not been used in this capacity before, therefore, there will be some process modifications required.

SCIENCE AND TECHNOLOGY NEEDS:

Process development is needed to improve efficiency and increase the extent of contaminant removal which can be achieved.

Development of amalgam electrowinning will be required. As stated before this technology is not available commercially.

IMPLEMENTATION NEEDS:

Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. The bench scale testing will also determine the cleanliness of the soil and cement and determine how many times the system should be repeated per amount of contamination. Process equipment for field work and scale up, will also be required.

COMMENTS:

Chemical Washing: A broad technological area where an unlimited number of process steps and chemical solutions are used to remove contaminants from a surface by cleaning or leaching and solubilizing them in a solvent. The application of specific technologies vary in maturity from very old and mature technologies used in the mining industry to conceptual methods for the removal of radionuclides from contaminated soils.

Amalgam Electrowinning: A developing electrochemical technology which uses mercury electrodes to reduce metal ions to the metallic state, whereupon, they are solvated (amalgamated) and removed from solution. The mercury electrode is regenerable and applicable to most metals and many radionuclides. Very high levels of metal removal are achievable.

EVALUATOR: Stuart K. Janikowski Phone (208) 526-0265
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REFERENCES:

None provided. For additional information, contact the above evaluator.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TAN V-1, TAN V-2, TAN V-3; OU 2-05, TRA-15.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 2-07, TRA-3C, TRA-39; OU 4-06, CFA-06

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Mixed low-level radioactive; hazardous-metals; laboratory waste-liquid.

Waste Form/Contaminants:

Soil, concrete and wood, lead chunks; silver, mercury plus radioisotopes/⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag, chromium and trivalent chromium; lead and lead oxide.

SUBELEMENTS: Biological and Chemical Treatments

ALTERNATIVES: Inorganic Concentrations from Liquids

TECHNOLOGY: Chemical Precipitation

STATUS: Research and development needed

This technology is currently available on the market. The method involves adding a chemical or chemicals to the contaminated liquid which will result in complexation or reduction and precipitation are forms of iron, sulfide, and hydroxide. This technology often requires close control of the solution pH during operation and secondary treatments to collect and dispose of the resulting sludge.

SCIENCE AND TECHNOLOGY NEEDS:

Technology development activities are needed to increase the extent of contaminant removal which can be achieved. Specific chemicals and pH levels will be required by a case by case basis. Developing a precipitation system which would be capable of targeting specific contaminants selectively rather than non-selectively would greatly enhance this technology.

IMPLEMENTATION NEEDS:

Hardware requirements for this technology are available and on the market. Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions.

COMMENTS:

For radionuclide contaminated liquids, regulatory issues determining clean-up levels will need to be defined.

EVALUATOR: Donald T. Maiers Phone (208) 526-6991
FAX (208) 526-5142

REFERENCES:

None provided. For additional information, contact the above evaluator.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TSF-06; OU 3-07, CPP-26, CPP-79.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-03, WRRTF-01.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-09; OU 5-12, PBF-08, PBF-10.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 4-06, CFA-44.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-29; OU 3-09, CPP-19; OU 3-12, CPP-80

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive, noncompactible; mixed low-level radioactive-metals; Hazardous-metals, organics.

Waste Form/Contaminants:

Soil, sludge, concrete and soil/¹³⁷Cs, ⁶⁰Co, ⁹⁰Sr, low levels of Pu, heavy hydrocarbons, Pb, chromium, lead and paint thinner.

SUBELEMENTS: Biological and Chemical Treatments

ALTERNATIVES: Soil Washing/Leaching

TECHNOLOGY: Chemical Washing

STATUS: Research and development needed

This technology is currently available on the market. The method involves agitating the soil in a slurry tank containing various combinations and concentrations of water, inorganic salts, mineral acids, complexing agents (generally proprietary), and often, specific surfactants, detergents, and heat. This procedure only cleans a fraction of the contaminated soil based on soil particle size and how the contaminants are bound to the soil particles. Often, different soil size fractions have different chemistry and therefore, bind contaminants differently. Due to this fact, this technology often requires a coupled treatment to separate the clean soil from the contaminated soil by sizing methods. The leachate produced from this technology also requires treatment.

SCIENCE AND TECHNOLOGY NEEDS:

Technology development activities are needed to increase the extent of contaminant removal which can be achieved. Specific chemicals and washing techniques will be required on a case by case basis. Developing a washing system which would be efficient for application to clays, silts, and fines would greatly enhance this technology.

IMPLEMENTATION NEEDS:

Hardware requirements for this technology are available and on the market. Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined. This technology may be applied to soils contaminated with both organics and inorganics/radionuclides.

EVALUATOR: Donald T. Maiers Phone (208) 526-6991
FAX (208) 526-5142

REFERENCES:

None provided. For additional information, contact the above evaluator.

INEL PROBLEM SITES:

Radioactive, underground storage tanks, aboveground storage tanks, and associated soils.

OU 2-05, TRA-15; OU 3-07, CPP-28, CPP-31

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 2-07, TRA-36, TRA-39; OU 4-06, CFA-06.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 3-08, CPP-15, OU 3-09, CPP-06; OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-35; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-22;
OU 3-11, CPP-58.

PROBLEM AREA/CONSTITUENTS:**Waste Types:**

Low-level radioactive-noncompactible; mixed low-level radioactive-noncompactible; radioactive; mixed radioactive; hazardous-organic; transuranic; Rocky Flats fire waste, Fu; fuel end boxes.

Waste Form/Contaminants:

Concrete; soil; soil and concrete; wood; soil and lead chunks; debris-paper, rags, sweepings, vehicles, diatomaceous earth, metal, glass; floor; soil and asphalt/⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag, ¹⁰⁶Ru, ¹³⁷Cs and ¹³⁴Cs at 200 mR/hr., mercuric nitrate, nitric acid, chromium, trivalent chromium, lead and lead oxide, plutonium at low levels, kerosene, tri-butyle phosphates, TCE, toluene and carbon tetrachloride, Pu.

SUBELEMENTS: Chemical and Biological Treatments

ALTERNATIVES: Soil Washing/Leaching

TECHNOLOGY: Chemical Washing

STATUS: Research and development needed

This technology is currently available on the market for treatment of soil, but not for concrete and other debris. The method involves agitating the soil in a slurry tank containing various combinations and concentrations of water, inorganic salts, mineral acids, complexing agents (generally proprietary), and often, specific surfactants, detergents, and heat. This procedure only cleans a fraction of the contaminated soil based on soil particle size and how the contaminants are bound to the soil particles. Often, different soil size fractions have different chemistry and therefore bind contaminants differently. Due to this fact, this technology often requires a coupled treatment to separate the clean soil from the contaminated soil by sizing methods. The leachate produced from this technology also requires treatment.

SCIENCE AND TECHNOLOGY NEEDS:

Technology development activities are needed to increase the extent of contaminant removal which can be achieved. Specific chemicals and washing techniques will be required on a case by case basis. Developing a washing system which would be efficient for application to clays, silts, and fines would greatly enhance this technology.

IMPLEMENTATION NEEDS:

Hardware requirements for this technology are available and on the market. Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. Effective implementation also requires coupling with secondary treatments such as chemical precipitation, bioaccumulation, bioprecipitation, ion exchange, etc.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined. This technology may be applied to soils contaminated with both organics and inorganics/radionuclides.

EVALUATOR: Stuart K. Janikowski Phone (208) 526-0265
FAX (208) 526-8541

REFERENCES:

None provided. For additional information, contact the above evaluator.

INEL PROBLEM SITES:

Radioactive, underground storage tanks, aboveground storage tanks, and associated soils.

OU 3-08, CPP-27

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-04, LOFT-02

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-06, TSF-07

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-36

PROBLEM AREA/CONTAMINANTS:**Waste Types:**

Mixed low-level radioactive-noncompactible; Corrosive; Metals; Hazardous-metals.

Waste Form/Contaminants:

Concrete; Soil/⁹⁰Sr, ¹³⁷Cs, ⁶⁰Co, Hg, ¹³⁴Cs, ¹⁵⁴Eu, mercuric nitrate, nitric acid, lead and mercury

SUBELEMENTS: Chemical and Biological Treatments

ALTERNATIVES: Soil Washing/Leaching

TECHNOLOGY: Chemical Washing

STATUS: Research and development needed

This technology is currently available on the market for treatment of soil, but not for concrete and other debris. The method involves agitating the soil in a slurry tank containing various combinations and concentrations of water, inorganic salts, mineral acids, complexing agents (generally proprietary), and often, specific surfactants, detergents, and heat. This procedure only cleans a fraction of the contaminated soil based on soil particle size and how the contaminants are bound to the soil particles. Often, different soil size fractions have different chemistry and therefore bind contaminants differently. Due to this fact, this technology often requires a coupled treatment to separate the clean soil from the contaminated soil by sizing methods. The leachate produced from this technology also requires treatment.

SCIENCE AND TECHNOLOGY NEEDS:

Research to determine the ability to remove mercury from the soils is needed. additional technology development activities are needed to increase the extent of contaminant removal which can be achieved. Specific chemicals and washing techniques will be required on a case by case basis. Developing a washing system which would be efficient for application to clays, silts, and fines would greatly enhance this technology.

IMPLEMENTATION NEEDS:

Hardware requirements for this technology are available and on the market. Implementation requires good characterization data and bench scale testing to optimize the process for the given conditions. Effective implementation also requires coupling with secondary treatments such as chemical precipitation, bioaccumulation, bioprecipitation, ion exchange, etc.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined. This technology may be applied to soils contaminated with both organics and inorganics/radionuclides.

EVALUATOR: Donald T. Maiers Phone (208) 526-6991
FAX (208) 526-5142

REFERENCES:

None provided. For additional information, contact the above evaluator.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TSF-06; OU 3-07, CPP-26, CPP-79.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-03, WRRTF-01;

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 3-08, CPP-15; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-09; OU 5-12, PBF-08, PBF-10.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 4-06, CFA-44.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-29, OU 3-09, CPP-10, CPP-19, OU 3-12, CPP-80.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive, noncompactible; Hazardous - organics, metals; mixed low-level radioactive - metals; hazardous - corrosives.

Waste Form/Contaminants:

Soil, concrete; sludge, concrete and soil, floor soil and asphalt/¹³⁷Cs ¹³⁴Cs, ⁶⁰Co, ⁹⁰Sr, ¹³⁷Cs and ¹³⁴Cs at 2 R/hr., low levels of Pu, nitric acid, heavy hydrocarbons, Pb, chromium, plutonium at low levels, kerosene, tri-butyle phosphates, hydrofluoric acid, aluminum nitrate, ¹³⁷Cs and ¹³⁴Cs at 200 mR/hr.

SUBELEMENTS: Biological and Chemical Treatments

ALTERNATIVES: Soil Washing/Leaching

TECHNOLOGY: Direct Biological Leaching

This technology consists of specific microbes being applied as a heap leach operation or in a stirred tank reactor. The leachate produced will contain the contaminate.

STATUS: Demonstration, testing and evaluation needed

This technology is used currently in the mining industry to solubilize metals from low-grade ores (30% of the U.S. copper is produced biologically). This has proven to be cost-effective for copper, uranium, cobalt, and manganese extraction. However, it is an unproven technology on non ore-like soils. This technology can be applied as a heap leach operation or in a stirred tank reactor. A slurry-phase reactor may require contact times that range from 4 to 48 hours. The

leachate produced will be three to seven times the volume of soil, and will necessarily contain the suspension of spent microbes from the reactor since it is likely that they have acted as sorbents for the contaminants. A heap leach operation is likely to require months of operation with a similar leachate production, but at a lower total cost.

SCIENCE AND TECHNOLOGY NEEDS:

Technology applicability will require evaluation on a site by site and case by case basis due to anticipated condition specificity. Evaluations will require detailed site characterization data and bench scale treatability studies. Specific factors requiring evaluation include the presence/absence of organics, concentrations of organics present, concentrations and forms of other nutrients such as nitrogen and phosphorus, direct toxicity of contaminants to microbial cultures used, toxicity of co-constituents to microbes, contaminant matrix, soil buffering capacity, presence and solubility of sulfides and chlorides, and specific ability of microbes to adsorb/absorb the contaminants.

IMPLEMENTATION NEEDS:

Hardware requirements for the stirred tank reactor (e.g., tanks, mixers, pH meters, pumps, augers) are available and on the market. Personnel operating this unit process would require a small amount of training and should be at a "technician" level. Hardware requirements for heap leaching (e.g., leach pads, liners, pumps, sprinkler pipe) are also available and on the market. Only part-time personnel would be required for this operation. For radionuclide contaminated soils, containment needs would require evaluation. Effective implementation also requires coupling with secondary treatments such as chemical precipitation, bioaccumulation, bioprecipitation, ion exchange, etc.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined. This technology may be applied to soils contaminated with both organics and inorganics/radionuclides. The microbes may degrade (destroy) the organics during the process of metabolism while liberating the inorganic/radionuclide and allowing it to be removed from the soil.

EVALUATOR: Donald T. Maiers Phone (208) 526-6991
FAX (208) 526-5142

REFERENCES:

- Williams, M., B. Pedersen, and S. S. Jorgensen, 1981, "Accelerated Leaching of Some Common and Trace Elements for Soil Mixed with Sewage Sludge or Sludge Ash", *Acta Agriculture Scandinavica*, Volume 31, pp. 323-342.
- Dave, S. R., and K. A. Natarajan, 1981, "Leaching of Copper and Zinc from Oxidized Ores by Fungi", *Hydrometallurgy*, Elsevier Scientific Publishing Company, Amsterdam, pp. 235-242.

Solozhenkin, P. M., L. L. Lyubavina, S. A. Sherepova, and N. N. Lyalikova, 1983, "The Role of Fungi in Beneficiation and Hydrometallurgy of Non-Ferrous Metals", *Progress in Biohydrometallurgy*, Cagliari, Italy, pp. 705-715.

Cripps, R. E., 1980, "The Recovery of Metals by Microbial Leaching", *Biotech Letters*, Volume 2, No. 5, pp. 225-230.

Lundgren, D. G., and E. E. Malouf, 1983, "Microbial Extraction and Concentration of Metals", *Adv. in Biotech. Processes*, Volume 1, pp. 223-249.

LeRoux, N. L., D. S. Wakerly, and V. F. Perry, 1980, "Leaching of Minerals Using Bacteria Other than Thiobacilli", *Basic Microbial Studies Applied to Leaching*, pp. 167-191.

INEL PROBLEM SITES:

Radioactive, underground storage tanks, aboveground storage tanks, and associated soils.

OU 2-05, TRA-15; OU 3-07, CPP-28, CPP-31.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 2-07, TRA-36, TRA-39; OU 4-06, CFA-06.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 3-09, CPP-06; OU 7-13, RWMC-04

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13, CPP-35; OU 3-09, CPP-03, CPP-08, CPP-11, CPP-17, CPP-22; OU 3-11, CPP-58.

PROBLEM AREA/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncombustible; mixed low-level radioactive-noncompactible; hazardous metals; radioactive; mixed radioactive; hazardous-organic; transuranic; Rocky Flats fire waste; Pu; fuel end boxes; low-level radioactive-noncompactible./ ⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag, ¹⁰⁶Ru, mercuric nitrate, nitric acid, chromium, trivalent chromium, lead and lead oxide, TCE, toluene and carbon, tetrachloride, Pu.

SUBELEMENTS: Chemical and Biological Treatments

ALTERNATIVES: Soil Washing/Leaching

TECHNOLOGY: Direct Biological Leaching

STATUS: Demonstration, testing and evaluation needed

This technology is used currently in the mining industry to solubilize metals from low-grade ores (30% of the U.S. copper is produced biologically). This has proven to be cost-effective for copper, uranium, cobalt, and manganese extraction. However, it is an unproven technology on non ore-like soils, and is most likely not applicable to concrete and other debris. This technology can be applied as a heap leach operation or in a stirred tank reactor. A slurry-phase reactor may require contact times that range from 4 to 48 hours. The leachate produced will be three to seven times the volume of soil, and will necessarily contain the suspension of spent microbes from the reactor since it is likely that they have acted as sorbents for the contaminants. A heap leach operation is likely to require months of operation with a similar leachate production, but at a lower total cost.

SCIENCE AND TECHNOLOGY NEEDS:

Technology applicability will require evaluation on a site by site and case by case basis due to anticipated condition specificity. Evaluations will require detailed site characterization data and bench scale treatability studies. Specific factors requiring evaluation include the presence/absence of organics, concentrations of organics present, concentrations and forms of other nutrients such as nitrogen and phosphorus, direct toxicity of contaminants to microbial cultures used, toxicity of co-constituents to microbes, contaminant matrix, soil buffering capacity, presence and solubility of sulfides and chlorides, and specific ability of microbes to adsorb/absorb the contaminants.

IMPLEMENTATION NEEDS:

Hardware requirements for the stirred tank reactor (e.g., tanks, mixers, pH meters, pumps, augers) are available and on the market. Personnel operating this unit process would require a small amount of training and should be at a "technician" level. Hardware requirements for heap leaching (e.g., leach pads, liners, pumps, sprinkler pipe) are also available and on the market. Only part-time personnel would be required for this operation. For radionuclide contaminated soils, containment needs would require evaluation. Effective implementation also requires coupling with secondary treatments such as chemical precipitation, bioaccumulation, bioprecipitation, ion exchange, etc.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined. This technology may be applied to soils contaminated with both organics and inorganics/radionuclides. The microbes may degrade (destroy) the organics during the process of metabolism while liberating the inorganic/radionuclide and allowing it to be removed from the soil.

EVALUATOR: Donald T. Maiers Phone (208) 526-6991
FAX (208) 526-5142

REFERENCES:

Williams, M., B. Pedersen, and S. S. Jorgensen, 1981, "Accelerated Leaching of Some Common and Trace Elements for Soil Mixed with Sewage Sludge or Sludge Ash", *Acta Agriculture Scandinavica*, Volume 31, pp. 323-342.

Dave, S. R., and K. A. Natarajan, 1981, "Leaching of Copper and Zinc from Oxidized Ores by Fungi", *Hydrometallurgy*, Elsevier Scientific Publishing Company, Amsterdam, pp. 235-242.

Solozhenkin, P. M., L. L. Lyubavina, S. A. Sherepova, and N. N. Lyalikova, 1983, "The Role of Fungi in Beneficiation and Hydrometallurgy of Non-Ferrous Metals", *Progress in Biohydrometallurgy*, Cagliari, Italy, pp. 705-715.

Cripps, R. E., 1980, "The Recovery of Metals by Microbial Leaching", *Biotech Letters*, Volume 2, No. 5, pp. 225-230.

Lundgren, D. G., and E. E. Malouf, 1983, "Microbial Extraction and Concentration of Metals", *Adv. in Biotech. Processes*, Volume 1, pp. 223-249.

LeRoux, N. L., D. S. Wakerly, and V. F. Perry, 1980, "Leaching of Minerals Using Bacteria Other than Thiobacilli", *Basic Microbial Studies Applied to Leaching*, pp. 167-191.

INEL PROBLEM SITES:

Radioactive, underground storage tanks, aboveground storage tanks, and associated soils.
OU 3-08, CPP-27.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 1-04, LOFT-02.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 1-06, TSF-07.

Radioactive spill areas, spill migrations, and unconfined disposal sites.
OU 3-08, CPP-36.

PROBLEM AREA/CONTAMINANTS:**Waste Types:**

Mixed low-level radioactive-noncompactible; corrosive; metals; hazardous-metals.

Waste Form/Contaminants:

Concrete; soil/⁹⁰Sr, ¹³⁷Cs, ⁶⁰Co, ¹³⁴Cs, ¹⁵⁴Eu, Hg, mercuric nitrate, nitric acid, lead, mercury.

SUBELEMENTS: Chemical and Biological Treatments

ALTERNATIVES: Soil Washing/Leaching

TECHNOLOGY: Direct Biological Leaching

STATUS: Demonstration, testing and evaluation needed

This technology is used currently in the mining industry to solubilize metals from low-grade ores (30% of the U.S. copper is produced biologically). This has proven to be cost-effective for copper, uranium, cobalt, and manganese extraction. However, it is an unproven technology on non ore-like soils and for mercury, and is most likely not applicable to concrete and other debris. This technology can be applied as a heap leach operation or in a stirred tank reactor. A slurry-phase reactor may require contact times that range from 4 to 48 hours. The leachate produced will be three to seven times the volume of soil, and will necessarily contain the suspension of spent microbes from the reactor since it is likely that they have acted as sorbents for the contaminants. A heap leach operation is likely to require months of operation with a similar leachate production, but at a lower total cost.

SCIENCE AND TECHNOLOGY NEEDS:

Technology applicability will require evaluation on a site by site and case by case basis due to anticipated condition specificity. Evaluations will require detailed site characterization data and bench scale treatability studies. Specific factors requiring evaluation include the presence/absence of organics, concentrations of organics present, concentrations and forms of other nutrients such

as nitrogen and phosphorus, direct toxicity of contaminants to microbial cultures used, toxicity of co-constituents to microbes, contaminant matrix, soil buffering capacity, presence and solubility of sulfides and chlorides, and specific ability of microbes to adsorb/absorb the contaminants.

IMPLEMENTATION NEEDS:

Hardware requirements for the stirred tank reactor (e.g., tanks, mixers, pH meters, pumps, augers) are available and on the market. Personnel operating this unit process would require a small amount of training and should be at a "technician" level. Hardware requirements for heap leaching (e.g., leach pads, liners, pumps, sprinkler pipe) are also available and on the market. Only part-time personnel would be required for this operation. For radionuclide contaminated soils, containment needs would require evaluation. Effective implementation also requires coupling with secondary treatments such as chemical precipitation, bioaccumulation, bioprecipitation, ion exchange, etc.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined. This technology may be applied to soils contaminated with both organics and inorganics/radionuclides. The microbes may degrade (destroy) the organics during the process of metabolism while liberating the inorganic/radionuclide and allowing it to be removed from the soil.

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REFERENCES:

Williams, M., B. Pedersen, and S. S. Jorgensen, 1981, "Accelerated Leaching of Some Common and Trace Elements for Soil Mixed with Sewage Sludge or Sludge Ash", *Acta Agricultura Scandinavica*, Volume 31, pp. 323-342.

Dave, S. R., and K. A. Natarajan, 1981, "Leaching of Copper and Zinc from Oxidized Ores by Fungi", *Hydrometallurgy*, Elsevier Scientific Publishing Company, Amsterdam, pp. 235-242.

Solozhenkin, P. M., L. L. Lyubavina, S. A. Sherepova, and N. N. Lyalikova, 1983, "The Role of Fungi in Beneficiation and Hydrometallurgy of Non-Ferrous Metals", *Progress in Biohydrometallurgy*, Cagliari, Italy, pp. 705-715.

Cripps, R. E., 1980, "The Recovery of Metals by Microbial Leaching", *Biotech Letters*, Volume 2, No. 5, pp. 225-230.

Lundgren, D. G., and E. E. Malouf, 1983, "Microbial Extraction and Concentration of Metals", *Adv. in Biotech. Processes*, Volume 1, pp. 223-249.

LeRoux, N. L., D. S. Wakerly, and V. F. Perry, 1980, "Leaching of Minerals Using Bacteria Other than Thiobacilli", *Basic Microbial Studies Applied to Leaching*, pp. 167-191.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TSF-06; OU 3-07, CPP-26, CCP-79.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-03, WRRTF-01.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-09; OU 5-12, PBF-08, PBF-10.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 4-06, CFA-44.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-29; OU 3-09, CPP-19, OU 3-12, CPP-80.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive noncompactible; Mixed low-level radioactive-metals; Hazardous-metals, organics.

Waste Form/Contaminants:

Soil, concrete, and soil, sludge/¹³⁷Cs, ¹³⁴Cs, ⁹⁰Sr, ⁶⁰Co, ¹³⁷Cs and ¹³⁴Cs at 2R/hr., low levels of Pu, heavy hydrocarbons, Pb; chromium, lead and paint thinner.

SUBELEMENTS: Biological and Chemical Treatments

ALTERNATIVES: Soil Washing/Leaching

TECHNOLOGY: Indirect Biological Leaching

STATUS: Demonstration, testing and evaluation needed

Specific microbial cultures would be grown for collection of microbially-produced acids (organic or inorganic) and/or other chelators. These products would be added to the contaminated soil in slurry-phase mixed reactors to leach the metals and/or radionuclides from the soil. The resulting leachate would be two to five times greater volume than the contaminated soil. The leachate would be collected and further treated to concentrate the contaminants as desired. This leaching process is relatively rapid and would require a slurry residence time of between ten minutes and two hours. The applicability of this technology is very likely site/soil/contaminant specific and would require evaluation on a case by case basis.

SCIENCE AND TECHNOLOGY NEEDS:

The amenability of each soil and contaminant combination to this type of leaching is different and would require evaluation. The exact treatment process parameters (e.g., pH, temperature, pulp density) would need to be defined in bench scale treatability studies for each different soil/contaminant condition, prior to technology implementation. The presence of large concentrations of organics in the soil may be detrimental to this type of leaching. This technology can not remove all of the contamination from the soil, but can be expected to remove as much as any other known technology.

IMPLEMENTATION NEEDS:

Hardware requirements (e.g., tanks, mixers, pH meters, pumps, augers) are available and on the market. Personnel operating the unit process would require a small amount of training and should be at a "technician" level. For radionuclide contaminated soils, containment needs would require evaluation. Effective implementation also requires coupling with secondary treatments such as chemical precipitation, bioaccumulation, bioprecipitation, ion exchange, etc.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined. This technology is actually a chemical treatment technology where the chemicals are produced biologically as a single step in the unit process.

EVALUATOR: Donald T. Maiers Phone (208) 526-6991
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REFERENCES:

- Williams, M., B. Pedersen, and S. S. Jorgensen, 1981, "Accelerated Leaching of Some Common and Trace Elements for Soil Mixed with Sewage Sludge or Sludge Ash", *Acta Agriculture Scandinavica*, Volume 31, pp. 323-342.
- Dave, S. R., and K. A. Natarajan, 1981, "Leaching of Copper and Zinc from Oxidized Ores by Fungi", *Hydrometallurgy*, Elsevier Scientific Publishing Company, Amsterdam, pp. 235-242.
- Solozhenkin, P. M., L. L. Lyubavina, S. A. Sherepova, and N. N. Lyalikova, 1983, "The Role of Fungi in Beneficiation and Hydrometallurgy of Non-Ferrous Metals", *Progress in Biohydrometallurgy*, Cagliari, Italy, pp. 705-715.
- Cripps, R. E., 1980, "The Recovery of Metals by Microbial Leaching", *Biotech Letters*, Volume 2, No. 5, pp. 225-230.
- Lundgren, D. G., and E. E. Malouf, 1983, "Microbial Extraction and Concentration of Metals", *Adv. in Biotech. Processes*, Volume 1, pp. 223-249.

LeRoux, N. L., D. S. Wakerly, and V. F. Perry, 1980, "Leaching of Minerals Using Bacteria Other than Thiobacilli", *Basic Microbial Studies Applied to Leaching*, pp. 167-191.

INEL PROBLEM SITES:

Radioactive, underground storage tanks, aboveground storage tanks, and associated soils.
OU 2-05, TRA-15; OU 3-07, CPP-28, CPP-31.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 2-07, TRA-36, TRA-39; OU 4-06, CFA-06.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 3-08, CPP-15; OU 3-09, CPP-06; OU 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.
OU 3-08, CPP-13, CPP-35; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-22;
OU 3-11, CPP-58.

PROBLEM AREA/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; mixed low-level radioactive-noncompactible;
hazardous-metals; radioactive; mixed radioactive; hazardous organic; transuranic; Rocky Flats fire
waste; Pu; fuel end boxes.

Waste Form/Contaminants:

Concrete and soil; concrete; soil; wood; soil and lead chunks; debris-paper, rags, sweepings,
vehicles, diatomaceous earth, wood, metal, glass; floor; soil; asphalt/⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs,
¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag, ¹⁰⁶Ru, ¹³⁷Cs and ¹³⁴Cs at 200 mR/hr., mercuric nitrate, nitric acid,
chromium, trivalent chromium, lead and lead oxide, plutonium at low levels, kerosene, tri-butyle
phosphates, TCE, toluene and carbon tetrachloride, Pu.

SUBELEMENTS: Chemical and Biological Treatments

ALTERNATIVES: Soil Washing/Leaching

TECHNOLOGY: Indirect Biological Leaching

STATUS: Demonstration, training and evaluation needed

Specific microbial cultures would be grown for collection of microbially-produced acids (organic or inorganic) and/or other chelators. These products would be added to the contaminated soil (this technology is most likely not applicable to contaminated concrete or debris) in slurry-phase mixed reactors to leach the metals and/or radionuclides from the soil. The resulting leachate would be two to five times greater volume than the contaminated soil. The leachate would be collected and further treated to concentrate the contaminants as desired. This leaching process is relatively rapid and would require a slurry residence time of between ten minutes and two hours. The applicability of this technology is very likely site/soil/contaminant specific and would require evaluation on a case by case basis.

SCIENCE AND TECHNOLOGY NEEDS:

The amenability of each soil and contaminant combination to this type of leaching is different and would require evaluation. The exact treatment process parameters (e.g., pH, temperature, pulp density) would need to be defined in bench scale treatability studies for each different soil/contaminant condition, prior to technology implementation. The presence of large concentrations of organics in the soil may be detrimental to this type of leaching. This technology can not remove all of the contamination from the soil, but can be expected to remove as much as any other known technology.

IMPLEMENTATION NEEDS:

Hardware requirements (e.g., tanks, mixers, pH meters, pumps, and augers) are available and on the market. Personnel operating the unit process would require a small amount of training and should be at a "technician" level. For radionuclide contaminated soils, containment needs would require evaluation. Effective implementation also requires coupling with secondary treatments such as chemical precipitation, bioaccumulation, bioprecipitation, ion exchange, etc.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined. This technology is actually a chemical treatment technology where the chemicals are produced biologically as a single step in the unit process.

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REFERENCES:

- Williams, M., B. Pedersen, and S. S. Jorgensen, 1981, "Accelerated Leaching of Some Common and Trace Elements for Soil Mixed with Sewage Sludge or Sludge Ash", *Acta Agriculture Scandinavica*, Volume 31, pp. 323-342.
- Dave, S. R., and K. A. Natarajan, 1981, "Leaching of Copper and Zinc from Oxidized Ores by Fungi", *Hydrometallurgy*, Elsevier Scientific Publishing Company, Amsterdam, pp. 235-242.
- Solozhenkin, P. M., L. L. Lyubavina, S. A. Sherepova, and N. N. Lyalikova, 1983, "The Role of Fungi in Beneficiation and Hydrometallurgy of Non-Ferrous Metals", *Progress in Biohydrometallurgy*, Cagliari, Italy, pp. 705-715.
- Cripps, R. E., 1980, "The Recovery of Metals by Microbial Leaching", *Biotech Letters*, Volume 2, No. 5, pp. 225-230.
- Lundgren, D. G., and E. E. Malouf, 1983, "Microbial Extraction and Concentration of Metals", *Adv. in Biotech. Processes*, Volume 1, pp. 223-249.

LeRoux, N. L., D. S. Wakerly, and V. F. Perry, 1980, "Leaching of Minerals Using Bacteria Other than Thiobacilli", *Basic Microbial Studies Applied to Leaching*, pp. 167-191.

INEL PROBLEM SITES:

Radioactive, underground storage tanks, aboveground storage tanks, and associated soils.
OU 3-08, CPP-27

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 1-04, LOFT-02

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 1-06, TSF-07

Radioactive spill areas, spill migrations, and unconfined disposal sites.
OU 3-08, CPP-36

PROBLEM AREA/CONSTITUENTS:**Waste Types:**

Mixed low-level radioactive-noncompactible; corrosive; metals; hazardous metals

Waste Form/Contaminants:

Concrete; soil/⁹⁰Sr, ¹³⁷Cs, ⁶⁰Co, Hg, ¹³⁴Cs, ¹⁵⁴Eu, mercuric nitrate, nitric acid, lead, mercury.

SUBELEMENTS: Chemical and Biological Treatments

ALTERNATIVES: Soil Washing/Leaching

TECHNOLOGY: Indirect Biological Leaching

STATUS: Demonstration, testing and evaluation needed

Specific microbial cultures would be grown for collection of microbially-produced acids (organic or inorganic) and/or other chelators. These products would be added to the contaminated soil (this technology is most likely not applicable to contaminated concrete or debris) in slurry-phase mixed reactors to leach the metals and/or radionuclides from the soil. The resulting leachate would be two to five times greater volume than the contaminated soil. The leachate would be collected and further treated to concentrate the contaminants as desired. This leaching process is relatively rapid and would require a slurry residence time of between ten minutes and two hours. The applicability of this technology is very likely site/soil/contaminant specific and would require evaluation on a case by case basis.

SCIENCE AND TECHNOLOGY NEEDS:

The amenability of each soil and contaminant combination to this type of leaching is different and would require evaluation (specifically, the ability to solubilize and remove mercury). The exact treatment process parameters (e.g., pH, temperature, pulp density) would need to be defined in bench scale treatability studies for each different soil/contaminant condition, prior to technology implementation. The presence of large concentrations of organics in the soil may be detrimental

to this type of leaching. This technology can not remove all of the contamination from the soil, but can be expected to remove as much as any other known technology.

IMPLEMENTATION NEEDS:

Hardware requirements (e.g., tanks, mixers, pH meters, pumps, augers) are available and on the market. Personnel operating the unit process would require a small amount of training and should be at a "technician" level. For radionuclide contaminated soils, containment needs would require evaluation. Effective implementation also requires coupling with secondary treatments such as chemical precipitation, bioaccumulation, bioprecipitation, ion exchange, etc.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined. This technology is actually a chemical treatment technology where the chemicals are produced biologically as a single step in the unit process.

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Solozhenkin, P. M., L. L. Lyubavina, S. A. Sherepova, and N. N. Lyalikova, 1983, "The Role of Fungi in Beneficiation and Hydrometallurgy of Non-Ferrous Metals", *Progress in Biohydrometallurgy*, Cagliari, Italy, pp. 705-715.

Cripps, R. E., 1980, "The Recovery of Metals by Microbial Leaching", *Biotech Letters*, Volume 2, No. 5, pp. 225-230.

Lundgren, D. G., and E. E. Malouf, 1983, "Microbial Extraction and Concentration of Metals", *Adv. in Biotech. Processes*, Volume 1, pp. 223-249.

LeRoux, N. L., D. S. Wakerly, and V. F. Perry, 1980, "Leaching of Minerals Using Bacteria Other than Thiobacilli", *Basic Microbial Studies Applied to Leaching*, pp. 167-191.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.
OU 2-05, TRA-15; OU 3-09, CPP-69.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-liquid,; Mixed low-level radioactive.

Waste Form/Contaminants:

Laboratory waste-liquid; liquid/¹³⁷Cs, ¹³⁴Cs, ¹⁴⁴Cs,
⁶⁰Co, ⁹⁰Sr, ⁵⁴Mn, ⁹⁷Nb, ¹⁵⁴Eu, ¹¹⁰Ag, silver, mercury, radioisotopes.

SUBELEMENTS: Biological and Chemical Treatments

ALTERNATIVES: Inorganic Concentration from Liquids

TECHNOLOGY: Bioaccumulation

STATUS: Research and development needed

This technology is currently available on the market to a limited extent. It involves using biomass (may be plant, fungal, or bacterial debris, proteins, or whole cells which may be living or dead) to adsorb/absorb the inorganic contaminants contained in the aqueous solutions. The biomass is then separated from the clean liquid and further processed/stored. Bioaccumulation of inorganics by this method may result in an ultimate concentration/volume reduction of up to several orders of magnitude. This technology may also be used to concentrate the inorganics from a multi-contaminant solution with a degree of specificity.

SCIENCE AND TECHNOLOGY NEEDS:

The ability to separate inorganics with a high degree of specificity would greatly enhance this technology. This would require laboratory research to identify specific biomass binding characteristics under given operating conditions.

IMPLEMENTATION NEEDS:

Tertiary treatment strategies (e.g., dewatering, incineration) to further reduce the volume of biomass/metal need to be planned and coupled to this technology in order to increase its effectiveness.

COMMENTS:

None.

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REFERENCES:

Horikoshi, T., A. Nakajima, and T. Sckaguchi, 1979, "Studies on the Accumulation of Heavy Metal Elements in Biological Systems", *Agricultural and Biological Chemistry*, Volume 43, pp. 617-623.

Benjamin, M. M., D. F. Hayes, and J. O. Leckie, 1982, "Removal of Toxic Metals from Power-Generated Waste Streams by Adsorption and Coprecipitation", *Journal of Water Pollution Control Federation*, Volume 55, Number 11, pp. 1471-1481.

Norris, P. R. and D. P. Kelley, 1979, "Accumulation of Metals by Bacteria and Yeasts", *Developmental and Industrial Microbiology*, volume 20, pp. 299-308.

Nakajamima, A., T. Horikoshi, and T. Sakaguchi, 1982, "Recovery of Uranium by Immobilized Microorganisms", *European Journal of Applied Microbiology and Biotechnology*, Volume 16, pp. 88-91.

INEL PROBLEM SITES:

Radioactive sumps, ponds, pits, trenches, rubble piles etc.

OU 2-09, TRA-07.

PROBLEM AREA/CONTAMINANTS:

Waste Types:

Low-level radioactive-noncompactible

SUBELEMENTS: Chemical and Biological Treatments

ALTERNATIVES: Inorganic Concentration from Liquids

TECHNOLOGY: Bioaccumulation

STATUS: Research and development needed

This technology is currently available on the market to a limited extent. It is limited to aqueous solutions and is not applicable to solids containing inorganics. The technology involves using biomass (may be plant, fungal, or bacterial debris, proteins, or whole cells which may be living or dead) to adsorb/absorb the inorganic contaminants contained in the aqueous solutions. The biomass is then separated from the clean liquid and further processed/stored. Bioaccumulation of inorganics by this method may result in an ultimate concentration/volume reduction of up to several orders of magnitude. This technology may also be used to concentrate the inorganics from a multi-contaminant solution with a degree of specificity.

SCIENCE AND TECHNOLOGY NEEDS:

The ability to separate inorganics with a high degree of specificity would greatly enhance this technology. This would require laboratory research to identify specific biomass binding characteristics under given operating conditions.

IMPLEMENTATION NEEDS:

Tertiary treatment strategies (e.g., dewatering, incineration) to further reduce the volume of biomass/metal need to be planned and coupled to this technology in order to increase its effectiveness.

COMMENTS:

None.

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Norris, P. R. and D. P. Kelley, 1979, "Accumulation of Metals by Bacteria and Yeasts", *Developmental and Industrial Microbiology*, volume 20, pp. 299-308.

Nakajamima, A., T. Horikoshi, and T. Sakaguchi, 1982, "Recovery of Uranium by Immobilized Microorganisms", *European Journal of Applied Microbiology and Biotechnology*, Volume 16, pp. 88-91.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.
OU 3-09, CPP-69.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive, liquid.

Waste Form/Contaminants:

Liquid/¹³⁴Cs, ¹³⁷Cs.

SUBELEMENTS: Biological and Chemical Treatments

ALTERNATIVES: Inorganic Concentration from Liquids

TECHNOLOGY: Bioprecipitation

STATUS: Demonstration, testing and evaluation needed

This technology involves the use of microbes to cause a precipitation of inorganics from solution. This may be accomplished by a metabolic reduction of the element (e.g., uranium) to a less soluble valence state, or by production of sulfides to bind with and subsequently precipitate the inorganics.

SCIENCE AND TECHNOLOGY NEEDS:

Bench scale studies to define the optimum operating conditions for these processes need to be conducted. Cost/benefit analyses need to be developed, based on the rate and extent of precipitation achievable by this process.

IMPLEMENTATION NEEDS:

Tertiary treatments to gather and treat/store the inorganic-laden sludge will be required.

COMMENTS:

None.

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REFERENCES:

Apel, W. A., M. R. Wiebe, and P. R. Dugan, 1990, "Separation and Concentration of Hazardous Metals from Aqueous Solutions Using Sulfate Reducing Bacteria", Bioprocessing Engineering Symposium, Volume 16, pp. 75-80.

Battacharyya, D. and L. F. Chen, 1986, "Sulfide Precipitation of Nickel and Other Heavy Metals from Single and Multi-Metal Systems, U.S. EPA Report #EPA/600/S2-86/051.

Tuttle, J. H., P. R. Dugan, C. B. MacMillan, and C. I. Randles, 1969, "Microbial Dissimilatory Sulfur Cycle in Acid Mine Water", *Journal of Bacteriology*, Volume 97, pp. 594-602.

Maiers, D. T., P. L. Thompson, and D. F. Bruhn, 1988, "Selenate Reduction by Bacteria from a Selenium-Rich Environment", *Applied and Environmental Microbiology*, Volume 10, pp. 217-263.

INEL PROBLEM SITES:

Radioactive, underground storage tanks, aboveground storage tanks, and associated spoils.

OU 2-05

PROBLEM AREA/CONTAMINANTS:

Waste Types:

Mixed low-level radioactive.

Waste Form/Contaminants:

Laboratory waste-liquid/⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹³⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag, silver, mercury, radioisotopes.

SUBELEMENTS: Chemical and Biological Treatments

ALTERNATIVES: Inorganic Concentration from Liquids

TECHNOLOGY: Bioprecipitation

STATUS: Demonstration, testing and evaluation needed

This technology involves the use of microbes to cause a precipitation of inorganics from solution (the process is ineffective on inorganics in solids or which are not solubilized). This may be accomplished by a metabolic reduction of the element (e.g., uranium) to a less soluble valence state, or by production of sulfides to bind with and subsequently precipitate the inorganics.

SCIENCE AND TECHNOLOGY NEEDS:

Bench scale studies to define the optimum operating conditions for these processes need to be conducted. Cost/benefit analyses need to be developed, based on the rate and extent of precipitation achievable by this process.

IMPLEMENTATION NEEDS:

Tertiary treatments to gather and treat/store the inorganic-laden sludge will be required.

COMMENTS:

None.

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Apel, W. A., M. R. Wiebe, and P. R. Dugan, 1990, "Separation and Concentration of Hazardous Metals from Aqueous Solutions Using Sulfate Reducing Bacteria", Bioprocessing Engineering Symposium, Volume 16, pp. 75-80.

Battacharyya, D. and L. F. Chen, 1986, "Sulfide Precipitation of Nickel and Other Heavy Metals from Single and Multi-Metal Systems, U.S. EPA Report #EPA/600/S2-86/051.

Tuttle, J. H., P. R. Dugan, C. B. MacMillan, and C. I. Randles, 1969, "Microbial Dissimilatory Sulfur Cycle in Acid Mine Water", *Journal of Bacteriology*, Volume 97, pp. 594-602.

Maiers, D. T., P. L. Thompson, and D. F. Bruhn, 1988, "Selenate Reduction by Bacteria from a Selenium-Rich Environment", *Applied and Environmental Microbiology*, Volume 10, pp. 217-263.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TSF-06; OU 3-07, CPP-26, CPP-28, CPP-79.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-09; OU 5-12, PBF-10.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-29; OU 3-09, CPP-19, CPP-22; OU 3-12, CPP-80,

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive, noncompactible; Mixed low-level radioactive, metals.

Waste Form/Contaminants:

Soil; concrete and SOIL /¹³⁷Cs, ¹³⁴Cs, ⁶⁰Co, ⁹⁰Sr, ¹³⁷Cs and ¹³⁴Cs at 2R/hr., low levels of Pu, chromium..

SUBELEMENTS: Biological and Chemical Treatments

ALTERNATIVES: In Situ Soil Remediation

TECHNOLOGY: Plant Uptake of Metals/Radionuclides.

STATUS: Demonstration, testing and evaluation needed

Specific plants are chosen based on environmental conditions and the contaminant requiring remediation. The plants are cultivated on the contaminated soil and as they grow, they uptake the contaminants from the soil through their roots and store them in varying locations within the plant. Often, the plant root zone (rhizosphere) is also manipulated such that special fungi (mycorrhizae) can assist the plants with the contaminant uptake. The plants are then harvested and further treated, and over a period of years (5 to 15) the surface soils (0-12 inches) are predominantly cleaned. This technology has been demonstrated in Europe with a number of heavy metals.

SCIENCE AND TECHNOLOGY NEEDS:

The specific plant(s) to be used at each site and for each contaminant would require evaluation prior to technology implementation. This technology could have a much broader applicability if the root zones could be encouraged to go deeper.

IMPLEMENTATION NEEDS:

Requirements to implement this technology include irrigation equipment, plant harvesting equipment, subsurface monitors to verify that the irrigation is not causing contaminant migration, secondary treatment for the harvested plants/plant parts, and for radionuclide contamination, a

containment facility to prevent the plants from being foraged by insects, birds, and other animals. This technology will need to be coupled with secondary treatment technologies to deal with the resulting contaminated biomass.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined. For treatment of metal contamination in surface soils, this is likely to be the most cost-effective solution providing the treatment time is not limiting. Cost estimates for radionuclides will primarily be based on the containment costs/requirements.

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REFERENCES:

Giordano, P. M., and A. D. Behel Jr., J. E. Lawrance, J. M. Solleau, and B. N. Bradford, 1983, "Mobility in Soil and Plant Availability of Metals Derived from Incinerated Municipal Refuse", *Journal of Environmental Science and Technology*, Volume 17, Number 4, pp. 193-198.

Chang, A. C., J. E. Warneke, A. L. Page, and L. J. Lund, 1984, "Accumulation of Heavy Metals in Sewage Sludge-Treated Soils", *Journal of Environmental Quality*, Volume 13, Number 1, pp. 87-91.

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Williams, D. E., J. Vlamix, A. H. Pukite, and J. E. Corey, 1980, "Trace Element Accumulation, Movement and Distribution in the Soil Profile from Massive Applications of Sewage Sludge", *Soil Science*, Volume 129, pp. 119-132.

Francis, C. W., S. S. Talmage, and B. B. McMullin, 1975, "Radionuclide Movement in Soils and Uptake by Plants a Selected Annotated Bibliography", Oak Ridge National Laboratory, Oak Ridge Tennessee.

INEL SITE PROBLEM:

Radioactive, underground storage tanks, aboveground storage tanks, and associated soils.

OU 2-05, TRA-15; OU 3-07, CPP-31.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 3-09, CPP-06

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-13; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17; OU 3-11, CPP-58

PROBLEM AREA/CONSTITUENTS:

Waste Types:

Low-level radiation-noncompactible; mixed low-level radioactivity-noncompactible.

Waste Forms/Contaminants:

Concrete and Soil; soil; floor; soil and asphalt/⁵⁴Mu, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ¹²⁷Cs, ⁹⁰Sr, ¹⁵⁴Eu, ¹¹⁰Ag, ¹³⁷Cs, ¹³⁴Cs at 200 mR/hr., mercuric nitrate, nitric acid, Hg.

SUBELEMENTS: Chemical and Biological Treatments

ALTERNATIVES: In Situ Soil Remediation

TECHNOLOGY: Plant Uptake of Metals/Radionuclides

STATUS: Demonstration, testing and evaluation needed

This technology is limited to soils and most likely ineffective for contaminated concrete and debris. Specific plants are chosen based on environmental conditions and the contaminant requiring remediation. The plants are cultivated on the contaminated soil and as they grow, they uptake the contaminants from the soil through their roots and store them in varying locations within the plant. Often, the plant root zone (rhizosphere) is also manipulated such that special fungi (mycorrhizae) can assist the plants with the contaminant uptake. The plants are then harvested and further treated, and over a period of years (5 to 15) the surface soils (0-12 inches) are predominantly cleaned. This technology has been demonstrated in Europe with a number of heavy metals.

SCIENCE/TECHNOLOGY NEEDS:

The specific plant(s) to be used at each site and for each contaminant would require evaluation prior to technology implementation. This technology could have a much broader applicability if the root zones could be encouraged to go deeper.

IMPLEMENTATION NEEDS:

Requirements to implement this technology include irrigation equipment, plant harvesting equipment, subsurface monitors to verify that the irrigation is not causing contaminant migration,

secondary treatment for the harvested plants/plant parts, and for radionuclide contamination, a containment facility to prevent the plants from being foraged by insects, birds, and other animals. This technology will need to be coupled with secondary treatment technologies to deal with the resulting contaminated biomass.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined. For treatment of metal contamination in surface soils, this is likely to be the most cost-effective solution providing the treatment time is not limiting. Cost estimates for radionuclides will primarily be based on the containment costs/requirements.

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Williams, D. E., J. Vlamix, A. H. Pukite, and J. E. Corey, 1980, "Trace Element Accumulation, Movement and Distribution in the Soil Profile from Massive Applications of Sewage Sludge", *Soil Science*, Volume 129, pp. 119-132.

INEL PROBLEM SITES:

Radioactive, underground storage tanks, aboveground storage tanks, and associated soils.

OU 3-08, CPP-27.

Nonradioactive sumps, ponds, pits, trenches, rubble piles etc.

OU 1-04, LOFT-02.

Radioactive sumps, ponds, pits, trenches, rubble piles etc.

OU 1-06, TSF-07.

Radioactive spill areas, spill migrations and unconfined disposal sites.

OU 3-08, CPP-36.

PROBLEM AREA/CONTAMINANTS:**Waste Types:**

Mixed low-level radioactive-noncompactible; corrosive; metals; hazardous-metals.

Waste Form/Contaminants:

Concrete; soil/⁹⁰Sr, ¹³⁷Cs, ⁶⁰Co, ¹³⁴Cs, ¹⁵⁴Eu, Hg, mercuric nitrate, nitric acid, lead, mercury.

SUBELEMENTS: Chemical and Biological Treatments

ALTERNATIVES: In Situ Soil Remediation

TECHNOLOGY: Plant Uptake of Metals/Radionuclides

STATUS: Demonstration, testing and evaluation needed

This technology is limited to soils and most likely ineffective for contaminated concrete and debris. Specific plants are chosen based on environmental conditions and the contaminant requiring remediation. The plants are cultivated on the contaminated soil and as they grow, they uptake the contaminants from the soil through their roots and store them in varying locations within the plant. Often, the plant root zone (rhizosphere) is also manipulated such that special fungi (mycorrhizae) can assist the plants with the contaminant uptake. The plants are then harvested and further treated, and over a period of years (5 to 15) the surface soils (0-12 inches) are predominantly cleaned. This technology has been demonstrated in Europe with a number of heavy metals.

SCIENCE AND TECHNOLOGY NEEDS:

The specific plant(s) to be used at each site and for each contaminant would require evaluation prior to technology implementation. Research will need to be conducted to verify that the mercury is not methylated and released to the atmosphere. Also, this technology could have a much broader applicability if the root zones could be encouraged to go deeper.

IMPLEMENTATION NEEDS:

Requirements to implement this technology include irrigation equipment, plant harvesting equipment, subsurface monitors to verify that the irrigation is not causing contaminant migration, secondary treatment for the harvested plants/plant parts, and for radionuclide contamination, a containment facility to prevent the plants from being foraged by insects, birds, and other animals. This technology will need to be coupled with secondary treatment technologies to deal with the resulting contaminated biomass.

COMMENTS:

For radionuclide contaminated soils, regulatory issues determining clean-up levels will need to be defined. For treatment of metal contamination in surface soils, this is likely to be the most cost-effective solution providing the treatment time is not limiting. Cost estimates for radionuclides will primarily be based on the containment costs/requirements.

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REFERENCES:

- Giordano, P. M., and A. D. Behel Jr., J. E. Lawrance, J. M. Solleau, and B. N. Bradford, 1983, "Mobility in Soil and Plant Availability of Metals Derived from Incinerated Municipal Refuse", *Journal of Environmental Science and Technology*, Volume 17, Number 4, pp. 193-198.
- Chang, A. C., J. E. Warneke, A. L. Page, and L. J. Lund, 1984, "Accumulation of Heavy Metals in Sewage Sludge-Treated Soils", *Journal of Environmental Quality*, Volume 13, Number 1, pp. 87-91.
- Slide, R. C., J. E. Hook, and L. T. Kardos, 1976, "Heavy Metal Application and Plant Uptake in a Land Disposal System of Wast Water", *Journal of Environmental Quality*, Volume 5, pp. 97-102.
- Williams, D. E., J. Vlamix, A. H. Pukite, and J. E. Corey, 1980, "Trace Element Accumulation, Movement and Distribution in the Soil Profile from Massive Applications of Sewage Sludge", *Soil Science*, Volume 129, pp. 119-132.
- Francis, C. W., S. S. Talmage, and B. B. McMullin, 1975, "Radionuclide Movement in Soils and Uptake by Plants a Selected Annotated Bibliography", Oak Ridge National Laboratory, Oak Ridge Tennessee.

INEL PROBLEM SITES:

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-11, CPP-45.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Hazardous, corrosives.

Waste Form/Contaminants:

Concrete; soil/Nitric acid, hydrofluoric acid, aluminum nitrate.

SUBELEMENTS: Biological and Chemical Treatments

ALTERNATIVES: Nitrates-Contaminated Media Remediation

TECHNOLOGY: Slurry/Liquid Biodentrification

STATUS: Demonstration, testing and evaluation needed

This technology is applicable to retrieved soils, sludges, and liquids contaminated with nitrates. It involves the placement of the contaminated media into a stirred-tank (as a liquid/slurry) containing a chosen microbial population, additional nutrients if needed, and controlled for pH, mixing, temperature, and residence time. The biodenitrification will result in nitrogen gas and clean sludge/liquid/biomass for disposal.

SCIENCE AND TECHNOLOGY NEEDS:

The scientific needs for application of this technology include the bench-scale tests required to define the optimal operating parameters for the specific remediation need.

IMPLEMENTATION NEEDS:

Hardware requirements to implement this technology are already available on the market.

COMMENTS:

This can be coupled with ion exchange/biosorption pretreatment technologies when metals/radionuclides are present in the media as co-contaminants.

EVALUATOR: Donald T. Maiers Phone (208) 526-6991
FAX (208) 526-5142

REFERENCES:

Tien, A. J. and G. F. Andrews. 1992. Denitrification of Nitrate Wastes by Alkalophilic Halophiles. Am. Soc. of Microbio. New Orleans, Louisiana, May, 1992.

Parker, D. S. et al. 1975. "Biological Denitrification", Chapter 5 in *Process Design Manual for Nitrogen Control*, U.S. Environmental Protection Agency, Technology Transfer, October, 1975.

INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38; OU 4-05, CFA-17.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 1-06, LOFT-01; OU 4-09, CFA-26, CFA-42.

Unexploded naval ordnance.

OU 10-03.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Hazardous-organics; Petroleum; hazardous-unexploded ordnance.

Waste Form/Contaminants:

Debris - glass and plastics; sludge; soil/Any metal or laboratory chemical, fuel oil spills, diesel fuel, No. 2 diesel fuel, fuel oil, TNT, RDX, composition B, lithium, tetryl, picric acid, smokeless powder, old black powder, ameto.

SUBELEMENTS: Biological and Chemical Treatments

ALTERNATIVES: Organically-Contaminated Soil Remediation

TECHNOLOGY: Landfarming

STATUS: Demonstration, testing and evaluation needed

This technology is applicable to surface soils contaminated with organics or to excavated subsurface soils spread out on the surface. The technology involves aerating the soils to a desired oxygen content, applying the appropriate moisture and nutrients (fertilizer), and monitoring the degradation of the organics. The bacteria indigenous to the soil will begin to degrade the organics as soon as the appropriate conditions are achieved. The treatment may take from 4 to 12 months to complete. In some cases, the vapors produced as a result of degradation may be considered a secondary waste stream requiring collection and treatment.

SCIENCE AND TECHNOLOGY NEEDS:

The scientific needs for this technology include the ability to achieve lower end-point concentrations, verify that the loss of organics is related to microbial degradation, and increase the rate of degradation.

IMPLEMENTATION NEEDS:

Requirements to implement this technology include irrigation equipment, plowing, disking, and chiseling equipment, and possibly a better liner technology to prevent water migration away from the treatment site. If capture and treatment of off-gas streams is required, an innovative

technology to accomplish that would be desirable as compared to enclosing the area with a tent or building structure.

COMMENTS:

This is a very simple and effective technology for remediation of hydrocarbons. Implementation for halocarbons requires slightly greater attention to process details.

EVALUATOR: Donald T. Maiers Phone (208) 526-6991
FAX (208) 526-5142

REFERENCES:

None provided. For additional information, contact the above evaluator.

INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38; OU 4-05, CFA-17.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 2-09, TRA-07.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 1-06, LOFT-01; OU 4-09, CFA-10, CFA-26 CFA-42; OU 7-08, R1/FS.

Unexploded naval ordnance.

OU 10-03, ordnance areas.

Landfills.

OU 4-12, CFA-02, CFA-03.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Hazardous-organics; Low-level radioactive, noncompactible; petroleum, municipal sanitary.

Waste Form/Contaminants:

Debris- glass and plastic; soil; sludge; liquid; concrete and soil; soil and gravel/Any metal or laboratory chemical; fuel oil spills; TCE, toluene, carbon tetrachloride, diesel fuel, PCB spill, No. 2 diesel fuel, paint thinner, chloroform, TNT, RDX, composition B, lithium, tetryl, picric acid, smokeless powder, old black powder, ameto.

SUBELEMENTS: Biological and Chemical Treatments

ALTERNATIVES: Organically-Contaminated Media Remediation

TECHNOLOGY: Slurry/Liquid Bioremediation

STATUS: Demonstration, testing and evaluation needed

This technology is applicable to retrieved fine soils, sludges, and liquids contaminated with organics. It involves the placement of the contaminated media into a stirred-tank (as a liquid/slurry) containing a chosen microbial population, additional nutrients and air if needed, and controlled for pH, mixing, temperature, and residence time. The biodegradation will result in clean sludge/liquid for discharge.

SCIENCE AND TECHNOLOGY NEEDS:

The scientific needs for application of this technology include the bench-scale tests required to define the optimal operating parameters for the specific remediation need.

IMPLEMENTATION NEEDS:

Hardware requirements to implement this technology are already available on the market.

COMMENTS:

This can be coupled with ion exchange/biosorption pretreatment technologies when metals/radionuclides are present in the media as co-contaminants.

EVALUATOR: Donald T. Maiers Phone (208) 526-6991
FAX (208) 526-5142

REFERENCES:

None provided. For additional information, contact the above evaluator.

Francis, C. W., S. S. Talmage, and B. B. McMullin, 1975, "Radionuclide Movement in Soils and Uptake by Plants a Selected Annotated Bibliography", Oak Ridge National Laboratory, Oak Ridge Tennessee.

INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-03, WRRTF-01.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 3-08, CPP-15; OU7-13, RWMC-04.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 4-06, CFA-44.

Landfills.

OU 4-12, CFA-02.

PROBLEM AREA/CONTAMINANTS:**Waste Types:**

Hazardous-metals, organics; Low-level radioactive-noncompactible; radioactive; mixed radioactive; hazardous-organic; transuranic; Rocky Flats fire waste; Pu; fuel end boxes; municipal sanitary.

Waste Forms/Contaminants:

Soil; concrete; debris-paper, rags, sweeping, vehicles, diatomaceous earth, wood, metal glass; liquid/Heavy hydrocarbons, Pb, plutonium at low levels, kerosene, tri-butyle phosphates, ⁶⁰Co, TCE, toluene, carbon, tetrachloride, Pu, lead and paint thinner, paint thinner.

SUBELEMENTS: Chemical and Biological Treatments

ALTERNATIVES: Organically-Contaminated Media Remediation

TECHNOLOGY: Slurry/Liquid Bioremediation

STATUS: Demonstration, testing and evaluation needed

This technology is applicable to retrieved fine soils, sludges, and liquids contaminated with organics. It involves the placement of the contaminated media into a stirred-tank (as a liquid/slurry) containing a chosen microbial population, additional nutrients and air if needed, and controlled for pH, mixing, temperature, and residence time. The biodegradation will result in clean sludge/liquid for discharge.

SCIENCE AND TECHNOLOGY NEEDS:

The scientific needs for application of this technology include the bench-scale tests required to define the optimal operating parameters for the specific remediation need. Additionally, the impacts of lead and other inorganic co-contaminants on this process will need to be assessed.

IMPLEMENTATION NEEDS:

Hardware requirements to implement this technology are already available on the market. This technology will need to be coupled with other unit processes targeting the inorganic contaminant fraction.

COMMENTS:

This can be coupled with ion exchange/biosorption pretreatment technologies when metals/radionuclides are present in the media as co-contaminants.

EVALUATOR: Donald T. Maiers Phone (208) 526-6991
FAX (208) 526-5142

REFERENCES:

None provided. For additional information, contact the above evaluator.

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INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 1-06, LOFT-01; OU 4-09, CFA-10, CFA-26 CFA-42; OU 7-08, R1/FS.

Unexploded naval ordnance.

OU 10-03, ordnance areas.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Hazardous-organics; unexploded ordnance.

Waste Form/Contaminants:

Soil; Debris - glass, plastic; soil and gravel; sludge/Any metal or laboratory chemical, diesel fuel, PCB spill, fuel oil, chloroform, TCE, toluene, carbon tetrachloride, TNT, ROX, composition B, lithium, tetra, picric acid, smokeless powder, old black powder, amotol.

SUBELEMENTS: Biological and Chemical Treatments

ALTERNATIVES: Organically-Contaminated Soil Remediation

TECHNOLOGY: Subsurface Bioremediation

STATUS: Demonstration, testing and evaluation needed

This technology is applicable to subsurface soils contaminated with organics. It involves the addition/injection of nutrients, organics (for certain halocarbon contaminants), air, and possibly microorganisms to the contaminated area to stimulate natural biodegradation in the region of the contamination. The biodegradation will result in clean soil in a time period of 12 to 36 months.

SCIENCE AND TECHNOLOGY NEEDS:

The scientific needs for this technology include the ability to achieve lower end-point concentrations, verify that the loss of organics is related to microbial degradation, and increase the rate of degradation. Advanced subsurface delivery systems are also needed. The single most critical need for subsurface biodegradation is the ability to conduct better modelling of the subsurface being remediated. This would result in information which could be used to optimize the delivery systems and define the requirements for the additives.

IMPLEMENTATION NEEDS:

Requirements to implement this technology include advanced drilling techniques, pumps, and sensors to monitor degradation and additive permeation.

COMMENTS:

This can be coupled with vacuum extraction technologies.

EVALUATOR: Donald T. Maiers Phone (208) 526-6991
FAX (208) 526-5142

REFERENCES:

None provided. For additional information, contact the above evaluator.

4. THERMAL AND PHYSICAL TREATMENT

INEL PROBLEM SITES:

Radioactive sumps, ponds, pits trenches, rubble piles, etc.

OU 1-05, TSF-21

PROBLEM AREAS/CONSTITUENTS:**WASTE FORM:**

Low-level radioactive-compactible

WASTE TYPE/CONSTITUENTS:

Debris-concrete and soil/ ^{137}Cs , ^{90}Sr , ^{60}Co

SUBELEMENTS: Retrieval

ALTERNATIVES: Manual material sizing

TECHNOLOGY: Manually operated portable crusher plant

STATUS: Accepted

Currently accepted and proven technology used by the construction and demolition industries for selective sizing or presizing of materials for initial use or reuse. Application is directly related to the remediation of problems similar to the identified site specific work tasks.

There are several types of manual operated portable crusher plants which are commercially available and technically proven. These would include the simple, single-stage, rock crushers to the complex multi-stage, metal separation, multiple screening, crushers. Each of these types of manual portable crusher plants have specific applications in which their physical characteristics will provide more efficient and cost effective material sizing and separation. Typically, the larger, multi-stage, metal separation, multiple screening, crushers are utilized for demolition-type applications.

Most of the Manual operated portable crusher plants are termed portable in that they can be transported to sites over existing roadway systems, however, they require some time in the initial setup and startup of operations (typically from one to two days for simple systems, to two to three weeks for the complex systems). All of the manual operated portable crusher plants have a large hopper area, an impact hammer crushing system (heavy impact-hammer with high momentum transfer large crushing forces to material), and various feed belt systems.

SCIENCE AND TECHNOLOGY NEEDS:

No new scientific investigation and/or technological development is necessary to fully implement commercially available equipment sized to meet the identified site specific work tasks.

These manual operated portable crusher plants vary in size and complexity to match almost any application for specific job site requirements. These crusher plants vary in size from a single truck

trailer to multiple truck/transport trailers. The smaller units have weights of 20,000 lbs. and the larger units have weights of 110,000 lbs. with 24-ton impact crusher and up to 600 tons per hour (TPH) production capacities. These larger units may require up to two or three transport trucks for moving to and from job sites. There are various crusher plant options which can be implemented to meet the job site needs such as the end product sizing. Various conveyors and prescreen and screen systems can be utilized to obtain numerous size variations and separations in the crushing process.

The more applicable "Recycler" type crusher plants are designed such that reinforced concrete chunks can be loaded into the crusher plant and the magnetic system will separate out the reinforcing steel from the concrete. This allow for the steel to be recycled and the concrete to be further crushed/screened/processed as required for reuse. These "Recycler" type crusher plants can also handle brick, concrete or pumice block, heavy ripper asphalt, demolition and construction rubble, dolomite limestone, wet clay, railroad ties, metal refuse, etc.

These crusher plants have a variety of impact crusher types and sizes depending upon the manufacturer and application. Some of these include three-stage rotor impact crushers, three-stage fixed blow bar impact crushers, etc. Some of the other variable subsystems of crusher plants are listed below:

- Hopper Systems
- Conveyor Feeding Systems
- Presizing Screen/Bars Systems
- Magnet Separator Systems
- Radial Stacking Conveyor Systems

IMPLEMENTATION NEEDS: None required.

COMMENTS:

There are several applications for the utilization of crushed/sized radioactive contaminated concrete at the INEL outlined in the Engineering Design File (EDF), ER&WM-D&D-050, D&D Technical Development/Applications, dated 24-Feb-93. Some of these would be the utilization of the crushed and sized concrete as a base material for future nuclear or contaminated construction projects (i.e. RWMC base material at bottom of trenches to provide all-weather access, base material for the ICPP new tank farm project, etc.).

EVALUATOR: Jack Prendergast

Phone (208) 526-8221

FAX (208) 526-2354

REFERENCES:

There are many manufacturers of crusher plants within the United States, including foreign Americanized companies. The "Buy American" philosophy should not bias the engineering decisions on the best equipment available.

The following is a listing of the major manufacturers of crusher plants and does not attempt to be a complete listing.

EXCAVATION EQUIPMENT MANUFACTURER

Allis Mineral Systems

P.O. Box 2219

2600 N. Roemer Rd.

Appleton, WI 54915

Phone: (414)734-9831

FAX: (414)734-9756

Astec Industries

P.O. Box 72787

4101 Jerrome Avenue

Chattanooga, TN 72787

Phone: (615)867-4210

FAX: (615)867-4636

Cedarapids, Inc.

916 16th Street NE

Cedar Rapids, IA 52402

Phone: (319)399-4771

FAX: (319)399-4871

Eagle Crusher Company

4250 S.R. 309

Galion, OH 44833

Phone: (419)468-2288

FAX: (419)468-4840

El-Russ Aggregate Equipment

Box 42, Site #1, RR #5

Calgary, Alberta,

Canada T2P 2G6

Phone: (403)279-7741

FAX: (403)236-5151

Excel

P.O. Box 31118

12100 I-40 East

Amarillo, TX 79120

Phone: (806)335-3737

FAX: (806)335-3949

Extec Screens & Crushers, Ltd.

Brightside Lane

Sheffield, S. York S92SR

United Kingdom

Phone: (0742) 562772

FAX: (0742) 562782

Finlay Hydrascreen USA Inc.

5820 Canton Center Rd. St. 165

Canton, MI 48187

Phone: (313)416-1270

FAX: (313)416-1273

Hartl Sieb-UND Brechtechnik GMBH

Brunnenstrasse 15

Ennsdorf, 4482, Austria

Phone: 43-7223-4652

FAX: 443-7223-4654

Hazemag USA Inc.

P.O. Box 1064

Mt. Braddock Rd.

Uniontown, PA 15401

Phone: (412)439-3512

FAX: (412)439-3514

Milwaukee Cylinder

950 Green Valley Rd.

Beaver Dam, WI 53916

Phone: (414)887-0317

FAX: (414)887-0841

Nordberg, Inc.

3073 South Chase Ave.

Milwaukee, WI 53207

Phone: (414)769-4461

FAX: (414)769-4730

Portec Construction Equipment

(Kloberg & Pioneer Products)

904 West 23rd Street

Yankton, SD 57078

Phone: (605)665-8771

FAX: (605)665-2623

R.B. (Lincoln) PK & Pegson Limited

Reevor Street

Lincoln, England LN6 FDJ

Phone: 01-144-522-525261

FAX: 01-144-522-512230

Telsmith, Inc.

P.O. Box 723

Milwaukee, WI 53201

Phone: (414)242-6600

FAX: (414)242-5812

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.

OU 1-05, TSF-PM2A; OU 3-07, CPP-31; OU 3-08, CPP-27;

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-04, LOFT-02; OU 4-05, CFA-04.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-06, TSF-07.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 1-06, TSF-08;

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-36

Landfills.

OU 4-12, CFA-02, CFA-03

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Hazardous, metals; Hazardous.

Waste Form/Contaminants:

Soil/Lead and mercury.

SUBELEMENT: Treatment - Thermal and Physical

ALTERNATIVE: Amalgamation

TECHNOLOGY: Amalgamation

STATUS: Research and development needed

It is not known whether this technology is beyond the bench-scale, pilot-scale study level.

Radioactively contaminated elemental mercury may have been treated at facilities by the generators themselves. Up to now, the INEL has treated mercury in a bench-scale mode to pass TCLP. Eventually, a pilot-scale unit will be permitted in one to two years.

SCIENCE AND TECHNOLOGY NEEDS:

The pilot-scale unit will require some testing since the equipment will differ slightly from the bench-scale equipment (INEL). It still needs to be determined if some DOE or comparable facility has developed this system at pilot level. It is fairly certain that there would be no commercial unit available presently to treat large quantities of radioactively contaminated elemental mercury.

IMPLEMENTATION NEEDS:

The equipment for performing this amalgamation would be fairly inexpensive (paint shaker). All debris or materials should be separated away from the mercury prior to amalgamation. If not much elemental mercury is present (<1 liter), bench-scale procedures should be adequate.

COMMENTS:

Contact at INEL: Ernest C. Garcia
WROC Technical Programs
Phone (208) 526-2975

EVALUATOR: Dave Tyson Phone (208) 526-5443
FAX (208) 526-1998

REFERENCES:

L. Rosengrant, "Treatment Technology Background Document", U.S. Environmental Protection Agency Office of Solid Waste, EPA/ 530-SW-90-059Z, January 1991.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.
OU 1-05, TSF-06, TSF-PM2A.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive, noncompactible.

Waste Form/Contaminants:

Debris-concrete, metal, and soil./¹³⁷Cs, ⁶⁰Co, and ⁹⁰Sr.

SUBELEMENT: Treatment - Thermal and Physical

ALTERNATIVE: Blasting Methods

TECHNOLOGY: CO₂ Blasting

This technology consists of liquid carbon dioxide being converted to a pellet state. The pellets are then entrained into a high pressure air stream and projected onto a surface being cleaned in a manner similar to sand or grit blasting.

STATUS: Demonstration, testing and evaluation needed

Technology has been in development over the last ten years and has been bench-scale tested at the Rocky Flats Plant on contaminated materials. Very effective in removing both loose, surface contamination, and fixed contamination. During Rocky Flats tests, cleaning rates ranged from approximately 50 to 90 lbs./hr. Basically, a line of sight cleaning method, limited effect around corners, or in deep channels. No secondary wastes are generated.

SCIENCE/TECHNOLOGY NEEDS:

Of the two systems tested at Rocky Flats, neither was totally efficient in the use of CO₂ pellets. One of the systems caused a buildup of ice on the object being cleaned and also in the room, causing the air filters to become clogged. Also, the decontamination room developed a buildup of CO₂ gas above OSHA allowable limits.

IMPLEMENTATION NEEDS:

Capital costs are in the order of \$300,000, and operating costs are estimated to range from \$15/hr., for industrial cleaning applications, to \$300/hr., for radioactive contamination removal. Equipment requirements include a pelletizer, to manufacture CO₂ pellets, an air compressor, an air dryer, and a liquid carbon dioxide storage tank. Also, an enclosure to contain the airborne contaminants and a HEPA filtration system to filter the exhaust air would be needed.

COMMENTS:

Evaluation complete.

EVALUATOR: Greg Hulet

Phone (208) 526-0283

FAX (208) 526-1998

REFERENCES:

United States Environmental Protection Agency, Hazardous Waste engineering Research Laboratory, "Guide for Decontaminating Buildings, Structures, and Equipment at Superfund Sites," EPA/600/2-85/028, March 1985.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.
OU 1-05, TSF-06.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 2-09, TRA-07; OU 3-8, CPP-15; OU 3-09, CPP-06.

Radioactive spill areas, spill migrations, and unconfined disposal sites.
OU 3-09, CPP-03, CPP-08, CPP-11, CPP-17, CPP-19, CPP-22, CPP-78; OU 3-11, CPP-58, CPP-80.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive, noncompactible.

Waste Form/Contaminants:

Debris-concrete and metal; soil; concrete/¹³⁷Cs, ¹³⁴Cs, ⁶⁰Co, ⁹⁰Sr, plutonium at low levels, kerosene, and tri-butyl phosphates.

SUBELEMENT: Treatment - Thermal and Physical

ALTERNATIVE: Blasting Methods

TECHNOLOGY: Water Crystal (Ice) Blasting

STATUS: Demonstration, testing and evaluation needed

Technology has been in development for several years, and has been tested on lead brick at the ORNL. Developed initially as a dust-free coating removal technique for confined spaces, the nonabrasive process was found to be ideal for sensitive activities such as aircraft paint removal. It has been shown to be very effective at removing both loose and fixed contamination. Secondary waste streams include water, which is generated at a rate of approximately 15 ga./hr.

SCIENCE/TECHNOLOGY NEEDS:

To have a trouble-free ice blast system, ice transport must be precise and quantitative. Ice packing will definitely prevent the process from being practical. A high efficiency blast nozzle is necessary to transfer energy from blast air to ice particles, allowing the ice particles to reach high velocities at low pressures.

IMPLEMENTATION NEEDS:

Operating costs are estimated at \$150K and typical production costs for ice are approximately \$5/ton. Equipment requirements include an ice maker, an ice-handling module, an air compressor, a refrigeration unit, and a blast nozzle.

COMMENTS:

Evaluation complete.

EVALUATOR: Jack Prendergast

Phone (208) 526-8221

FAX (208) 526-2354

REFERENCES:

None provided. For additional information, contact the above evaluator.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soils.
OU 1-05, TSF-06.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Low-level radioactive.

Waste Form/Contaminants:

Debris - Concrete and metals/ ¹³⁷Cs, ⁶⁰Co, and ⁹⁰Sr.

SUBELEMENTS: Treatment - Thermal and Physical

ALTERNATIVES: Blasting Methods

TECHNOLOGY: Sand Blasting

This technology consists of uniform sand grains being entrained into a high pressure air stream and then projected onto a surface being cleaned.

STATUS: Accepted

A long standing, successful, and well understood technology. No further discussion needed.

SCIENCE TECHNOLOGY NEEDS:

None.

IMPLEMENTATION NEEDS:

Minimal.

COMMENTS:

None.

EVALUATOR: Jack Pendergast Phone (208) 526-8221
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REFERENCE:

United States Environmental Protection Agency, Hazardous Waste engineering Research Laboratory, "Guide for Decontaminating Buildings, Structures, and Equipment at Superfund Sites," EPA/600/2-85/028, March 1985.

Grit Blasting, DCON-38-OG, Oak Ridge K-25 Site Technology Logic Diagram, Document K-2073, February 26, 1993.

INEL PROBLEM SITES:

Radioactive, underground storage tanks, aboveground storage tanks, and associated soils.
OU 3-09, CPP-69.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 5-12, PBF-08.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive, liquid, and noncompactible.

Waste Form/Contaminants:

Liquids and sludge/ ^{137}Cs , ^{134}Cs , and ^{60}Co .

SUBELEMENTS: Treatment - Thermal and Physical

ALTERNATIVES: Evaporation

TECHNOLOGY: Evaporation

This technology consists of separating volatile compounds at optimum temperature and pressure by using evaporation followed by condensation.

STATUS: Accepted

Many types of variations of evaporators are available. The most common designs used for radioactive liquid wastes include pot, kettle, or pan evaporators, natural circulation systems, and forced circulation systems. They are operated as batch, semibatch, and continuous processes. The complexity of the design is dependent on the type and degree of separation required.

SCIENCE AND TECHNOLOGY NEEDS:

For new applications, the degree of separation would have to be investigated. Foaming and scaling problems are common, requiring special measures for each application.

IMPLEMENTATION NEEDS:

Field tests would be required to establish separation efficiency and potential operational problems. Energy requirements are high.

COMMENTS:

Evaluation complete.

EVALUATOR: Gregory A. Hulet Phone (208) 526-0283

FAX (208) 526-8661

REFERENCES:

DOE National Low-Level Radioactive Waste Management Program Handbook Series,
"Low-Level Radioactive Waste Treatment Technology." DOE/LLW-13Tc, July 1984.

A. A. Moghissi, H. W. Godbee, and S. A. Hobart, Radioactive Waste Technology." New York:
American Society of Mechanical Engineers, 1986.

H. M. Freeman, Editor, "Standard Handbook of Hazardous Waste Treatment and Disposal," New
York's McGraw-Hill Book Company, 1989.

INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 4-05, CFA-17

Nonradioactive spill areas, spill migrations, and unconfined disposal sites

OU 4-09, CFA-10, CFA-26

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Hazardous-organics (PCB spill)(fuel oil) and petroleum (No. 2 Diesel oil).

Waste Form/Contaminants:

Soil and gravel.

SUBELEMENTS: Thermal and Physical**ALTERNATIVES:**

Water based reactive plasma for hazardous organic liquid wastes destruction

TECHNOLOGY: Water Based Reactive Plasma

This technology provides a device and a method using a water vortex to generate a reactive plasma to destroy hazardous and inert organic fluid wastes (see Figure 1).

A water based reactive plasma is generated in a vortex tube where the organic liquid wastes are fed into a high velocity water vortex. A plasma jet discharging through the vortex tube will heat the feed materials to temperatures in excess of 2,500K. The high velocity water vortex confines the plasma and to provide a continuous interface between the super heated gas and the liquid to form a reactive plasma. The super heated plasma gas evaporates and dissociates the water into O, O⁺, O_x, OH, H, and H₂ reactive species, and the organic materials into their constituents. The intense ultra-violet radiation generated by the plasma jet also enhances the organic molecule breakdown processes in the plasma. These components participated in chemical reactions at very high temperatures to render the hazardous organics into harmless components. If halogens and sulfides are present in the organics, a base, NaOH or KOH, can be used in the water stream to render the halogens (F, Cl, Br, and I) and sulfur to harmless and condensable solids. If NO_x and SO_x are formed in the process, they will be dissolved in excess water vapor and collected as condensed acids. Excess water from the water vortex is collected at the exit of the vortex tube and is recirculated back in to the processing stream. A bottom arc heater unit attached to the vortex tube provided additional high temperature oxidation for any escaped residue organic in the gas stream and maintains a high system overall destruction removal efficiency (DRE).

STATUS: Research and development needed

This is a conceptual technology which had limited initial testings at the INEL. This technology needs further support for development. A bench scale model has been developed at the INEL.

Figure 1. Proposed zero waste discharge modifications to Liquid Injection Plasma Deposition (LIPD) system.

This working model has produced excellent results in dissociation of test solutions with a flow rate of 1-4 gallons per hour. Further development of the technology would require upscale of the unit, surrogate waste testing, and regulatory requirements, evaluation (e.g., PCB destruction, permitting). This technology shows excellent potential for further development to fully treat RCRA/TSCA liquid, organic, and radiologically mixed organic waste streams, on a large scale. Development costs could range from 500K to 1000K.

SCIENCE AND TECHNOLOGY NEEDS:

Process development is needed to determine the process DRE and to demonstrate the process economics. This technology only needs short term development to make it a viable compact system for on-line waste destruction for commercial production processes.

IMPLEMENTATION NEEDS:

Implementation of the process commercially requires research and development of the bench scale and good characterization of the test data for EPA approval. Bench scale development data

are needed to optimize the process, to evaluate the process scaling potential and the process economics. Process and analytical equipment will be needed for the bench scale development.

COMMENTS:

This is a newly developed technology being researched at the time.

EVALUATOR: A. D. Watkins Phone (208) 526-1217
FAX (208) 526-0690

REFERENCES:

No published documents exist for this technology.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated spills.

OU 2-05, TRA-15; OU 3-07, CPP-31; OU 3-08, CPP-27

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-09, CPP-10

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive-noncompactible; mixed low-level radioactive-noncompactible.

Waste Form/Contaminants:

Cement and soil/⁵⁴Mn, ⁹⁷Nb, ⁶⁰Co, ¹³⁴Cs, ¹⁴⁴Cs, ⁹⁰Sr, ¹⁵⁴Eu, and ¹¹⁰Ag, mercuric nitrate, and nitric acid.

SUBELEMENTS: Thermal and Physical**ALTERNATIVES: Ex-situ vitrification.****TECHNOLOGY: Minimum Additive Waste Stabilization (MAWS)**

A technology system centered on vitrification that incorporates low level radioactive mixed wastes into a stable final glass/glassy slag waste form. Wastes are utilized as resources for additives to minimize the volume of final waste for disposal. Minimization of volume and risk related to disposal of a stable, durable waste form is expected to produce substantial cost benefits.

STATUS: Research and development

Initial demonstration at Fernald is a low-temperature joule melter which incorporates soil washing and ion exchange water treatment. It is being demonstrated to stabilize contaminated sludges (contaminated with magnesium fluoride, low-level organics, toxic metals, uranium) soils, and flyash into one waste form. The technology system is essentially closed-loop with secondary wastes produced from offgas scrubbing being recycled back to the melter. laboratory scale melter systems (10kg/day, 100 kg/day glass) have been demonstrated using the system concept and have been successful for actual radioactive Fernald wastes to produce a quality final glass form and excellent offgas treatment and recycle of secondary wastes. Waste forms pass EPA TCLP leachability tests, and compare favorably with the Product Consistency Test (extended leach tests ranging from 7 to 180+ days) results for high-level standard glass. Leaching tests also show very little evidence of radioactive leaching and the results are much lower than the site determined cleanup levels. Additional durability tests conducted reveal little evidence of deterioration or formation of secondary phases in the glass. The quality final waste form has potential for disposal cost savings. The system at Fernald is a scaled-up version (300 kg/day glass) of the laboratory system and is in cold-phase testing. Radioactive testing is estimated to commence in October, 1993. Initial total life-cycle costs estimations for Fernald demonstration show that MAWS is a

cost effective alternative to cementation and can save Fernald millions of dollars in remediation. Additional verification costs estimations are expected in FY-94.

The low-temperature joule melter has certain limitations and other technologies are being investigated for MAWS, particularly in the case of higher level organics, and wastes containing bulk metals. Again the focus will be on total system approach to address primary treatment, offgas treatment, secondary waste handling, and production of a stable final waste form for disposal. Preliminary studies have been conducted on acceptable soil/metal ratios using the plasma centrifugal furnace which indicate promising results, but requires further investigation. Additional high temperature treatments are being evaluated for use in the MAWS program in FY-94/FY-95.

SCIENCE AND TECHNOLOGY NEEDS:

Fernald experience shows promise of vitrification of LLMW streams. There is a need to develop additional MAWS technologies and apply them to DOE complex needs. This will be done by choosing wastes that are site specific, but also relevant to the needs of the complex. Additional work will be done in FY-94 to identify a compositional window of waste streams/constituents that will produce a quality final waste form using the MAWS concept. Depending on the wastes present at the sites, technologies systems will be chosen for investigation of the MAWS concept. The system approach will require addressing volatilization of species in the offgas, pretreatment of problem wastes such as mercury or sulfate containing streams, feasibility of secondary stream recycle, etc.

IMPLEMENTATION NEEDS:

Actual waste streams from the sites require testing initially to determine feasibility of producing a quality waste form as was done for Fernald wastes. Follow-up testing to determine larger scale processing parameters/feasibility would also be required.

COMMENTS:

None.

EVALUATOR: Dave Tyson Phone (208) 526-5443
Fax (208) 526-1998

REFERENCES:

Chris Chapman
Battelle Pacific Northwest Laboratories
(509) 376-6576

INEL PROBLEM SITES:

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.
OU 1-06, TSF-08.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Hazardous - metals, recyclables.

Waste Form/Contaminants:

Soil, lead chunks, lead shot, bricks, and batteries/Mercury, lead, lead oxide, and metal.

SUBELEMENTS: Treatment - Thermal and Physical

ALTERNATIVES: Gravity Based Separations

TECHNOLOGY: Centrifugal Separation

STATUS: Accepted

Centrifugation is an off-the-shelf technology that can be tailored to a variety of applications. It could easily be modified for use with radioactive or mixed wastes.

SCIENCE AND TECHNOLOGY NEEDS:

Plugging of a centrifugal system is a common problem that would have to be resolved for each application. Below 0.5 wt% solids, separation is ineffective. Incomplete separations necessitate secondary treatments.

IMPLEMENTATION NEEDS:

Depending on the separation required, field tests would be needed to determine the efficiency of the system. Secondary treatment systems would have to be designed and installed.

COMMENTS:

Evaluation complete.

EVALUATOR: Greg Hulet

Phone (208) 526-0283

FAX (208) 526-1998

REFERENCES:

S. D. Clinton, "Low-Level Radioactive Waste Treatment Technology,"
DOE/LLW-13Tc

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INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38; OU 4-06, CFA-43

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

ou 7-13, RWMC-04.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-09, CPP-10.

PROBLEM AREAS/CONTAMINANTS:**Wastes Types:**

Low-level radioactive, noncompactible; Hazardous - organics, transuranic, Rocky Flats fire waste Pu, fuel end boxes, metals, recyclables; and Radioactive, mixed radioactive.

Waste Form,/Contaminants:

Debris - concrete, metals, glass, plastics, paper, rags, sweepings, vehicles, diatomaceous earth, wood; Soil; Lead chunks, lead shot, bricks, batteries, floor, and asphalt/¹³⁷Cs, ⁶⁰Co, ⁹⁰Sr, ¹³⁷Cs, ¹³⁴Cs at 300 mR/hr.; any metal or laboratory chemical, lead, mercury, lead oxide, metal, TCE, toluene and carbon tetrachloride Pu.

SUBELEMENTS: Treatment - Thermal and Physical

ALTERNATIVES: Screening and Sorting

TECHNOLOGY: Screening and Sorting Methods

STATUS: Demonstration, testing and evaluation needed

Screening and sorting methods have been used successfully in the mining, pulp and paper, chemical, and hazardous waste treatment industries. Mixed waste employment of sorting methods are in the developmental stages requiring demonstration to prove their reliability. The screening methods, as referred to, are mechanical separations utilizing screening machines which are classified as grizzlies, revolving screens or trommels, vibrating screens, and shaking screens. The screening methods need additional demonstration. Sorting methods are classified as manual, magnetic, and air classifiers. Manual methods for mixed and low-level waste sorting are typically labor and capital intensive, utilizing hot cell, robotics, and glove-box techniques.

SCIENCE AND TECHNOLOGY NEEDS:

Continued development is needed to better and more cost effectively employ these technologies in the radioactive waste treatment areas. Robotics, in particular, is an area that requires additional development and demonstration before it can be considered a proven technology. The other screening and sorting methods are less developmental, but require additional development focused on reducing their maintenance requirements.

IMPLEMENTATION NEEDS:

Both equipment and operating costs are typically high for employment of this technology. The costs impact warrant a very close scrutiny of the waste characteristics and resultant waste processing before deciding on the methods of screening and sorting to employ.

COMMENTS:

Evaluation complete.

EVALUATOR: Donald J. Kenoyer

Phone (208) 526-9837

FAX (208) 526-2714

REFERENCES:

None provided. For additional information, contact the above evaluator.

INEL PROBLEM SITES:

Radioactive, underground storage tanks, aboveground storage tanks, and associated soils.

OU 1-05, TAN V-1, TAN V-2, TAN V-3, TSF-PM2A; OU 2-05, TRA-15; OU 3-07, CPP-79; OU 3-09, CPP-69.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38, TSF-03, WRRTF-01; OU 1-04, LOFT-02; OU 4-06, CFA-06, CFA-43.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 7-13, RWMC-04.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 7-08, RI/FS.

Landfills.

OU4-12, CFA-02, CFA-03.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low level radioactive-noncompactible, liquid; Mixed low level radioactive-metal; Hazardous metals-recyclable; Radioactive, mixed radioactive, hazardous-organics, transuranic Rocky Flats fire waste, Pu, fuel end boxes; and Municipal sanitary.

Waste Form/Contaminants:

Soil, concrete, wood, sludge, laboratory waste, liquid, lead chunks, debris-paper, rags, sweepings, vehicles, diatomaceous earth, metal and glass; floor and asphalt/¹³⁷Cs, ¹³⁴Cs, ¹⁴⁴Cs, ⁶⁰Co, ⁹⁰Sr, Silver, mercury, plus radioisotopes, ⁵⁴Mn, ⁹⁷Nb, ¹⁵⁴Eu, ¹¹⁰Ag, chromium, trivalent chromium, lead and lead oxide, lead shot, bricks, batteries, Hg, TCE, TCA, xylene in parts per billion, ⁶⁰Co(1000pCi/g) ²³⁹Pu, ²⁴⁰Pu(1pCi/g), ¹⁵⁴Eu(5pCi/g), toluene, carbon tetrachloride, ¹³⁷Cs and ¹³⁴Cs at 200mR/hr.; paint thinner, beryllium and trichloroethane.

SUBELEMENTS: Treatment - Thermal and Physical

ALTERNATIVES: Solidification/Stabilization

TECHNOLOGY: Cementitious

This technology incorporates the waste into a cement matrix using portland cement.

STATUS: Accepted

Cementitious treatment using Portland Cement has been used extensively for treatment of LLW in the nuclear power industry. It has also been used frequently for treatment of RCRA

hazardous waste where S/S has been determined Best Demonstrated Available Technology (BDAT).

SCIENCE AND TECHNOLOGY NEEDS:

Additional development work is needed to develop cement formulations for mixed waste containing oil and grease, and to minimize the increase in the treated waste volume. This should be focused on known large amounts of mixed waste for which cementitious S/S is judged to be a top candidate treatment method.

IMPLEMENTATION NEEDS:

Cementitious systems utilize solids handling equipment such as belt conveyors, liquid/solid mixers, gravimetric feed belts, and feed hoppers with vibrating bin-bottoms for cement and other solid additives.

COMMENTS:

This review is considered complete.

EVALUATOR: Kevin Gering

Phone (208) 526-5936

REFERENCES:

DOE National Low-Level Radioactive Waste Management Handbook Series, "Low-Level Radioactive Waste Treatment Technology," DOE/LLW-13Tc, July 1984.

"Options for the Treatment and Solidification of Organic Radioactive Wastes," Technical Report Series No. 294, Vienna: International Atomic Energy Agency, 1989.

INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 4-06, CFA-06, CFA-43.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 7-13, RWMC-04.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Mixed low-level radioactive; Hazardous - metals, organics, recyclables; Noncompactible; Radioactive; Mixed radioactive, Hazardous - organic, transuranic, Rocky Flats fire waste, Pu; fuel end boxes; Low-level radioactive - noncompactible; Low-level radioactive

Waste Form/Contaminants:

Laboratory waste and laboratory liquid waste; Soil, concrete, wood, lead, and lead oxide; Metal and lead, lead shot, bricks, and batteries; Sludge; Debris - paper, rags, sweepings, vehicles, diatomaceous earth, and glass; Paint thinner; Floor and asphalt/Silver, mercury, radioisotopes, TCE, TCA, xylene in parts per billion, ^{54}Mn , ^{97}Nb , ^{60}Co , $^{60}\text{Co}(1000\text{pCi/g})$, ^{134}Cs , ^{144}Cs , ^{137}Cs , ^{90}Sr , ^{154}Eu , $^{154}\text{Eu}(5\text{pCi/g})$, ^{110}Ag , ^{240}Pu , $^{240}\text{Pu}(1\text{pCi/g})$, lead, chromium, trivalent chromium, lead oxide, metal, toluene, carbon tetrachloride Pu, paint thinner, ^{137}Cs and ^{134}Cs at 200 mR/hr.

SUBELEMENTS: Treatment - Thermal and Physical

ALTERNATIVES: Solidification/Stabilization

TECHNOLOGY: Polymer Solidification

This technology incorporates the waste into a polymer matrix using various polymers.

STATUS: Demonstration, testing and evaluation needed

In situ microencapsulation exists for polymer encapsulation of spent ion exchange resins used in removing radionuclides from liquid streams. Dewatering of the ion exchange resins is required prior to addition of binder. Microencapsulation takes place in the drum as fluid material fills the voids and solidifies/polymerizes. Diversified Technologies uses a vinyl ester resin in situ system (VERI), and the monolith is created by a polymerization reaction between monomer, catalyst, and promoter. Other processes use molten polyethylene which is pumped to the drum using a heated extruder. These are basically off-the-shelf items.

SCIENCE AND TECHNOLOGY NEEDS:

The technology has been developed for radioactively contaminated spent ion exchange resins. If this technology was to be used on hazardous material requiring a TCLP test, further development and testing would be required to determine what types of matrices would be amenable to passing

TCLP (e.g., ion exchange resins would most likely represent an adequate matrix with heavy metal dispersion throughout on an ionic level).

IMPLEMENTATION NEEDS:

Due to a new EPA ruling in 40 CFR regarding treatment of hazardous debris, the use of polymer treatment (encapsulation) will provide sufficient treatment for some hazardous debris types. A trial in situ study will exist this spring at ATR by microencapsulating circuit boards.

COMMENTS:

Evaluation complete.

EVALUATOR: Dave Tyson Phone (208) 526-5443
FAX (208) 526-1998

REFERENCES:

Vendor contact: Charles Jensen 301-7783842, Diversified Technologies

Technical report: Brookhaven National Laboratory, Upton, NY 11973, Report BNL-52126

Vendor contact: Ronald Burnham, 206-874-2235, Pacific Nuclear

INEL PROBLEM SITES:

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 1-06, TSF-07; OU 5-12, PBF-10.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive, noncompactible; Mixed low-level radioactive, noncompactible, corrosive, metals; Hazardous, organics, metals; Mixed low-level radioactive, noncompactible, corrosive, metals; Indeterminate.

Waste Form/Contaminants:

Soil, concrete, and sediment/¹³⁷Cs, ⁶⁰Co, ⁹⁰Sr, Hg, TCE, TCA, xylene in parts per billion, ¹³⁷Cs(1000pCi/g), ²³⁹Pu, ²⁴⁰Pu,(1pCi/g), ¹³⁴Cs, ¹⁵⁴Eu, ⁹⁰Sr(5pCi/g), ¹³⁷Cs and ¹³⁴Cs at 2R/hr., lead, mercuric nitrate, nitric acid, heavy hydrocarbons Pb, and chromium.

SUBELEMENTS: Treatment - Thermal and Physical

ALTERNATIVES: Solidification/Stabilization

TECHNOLOGY: In Situ Auger Injection

STATUS: Accepted

In Situ Fixation Co. has dual auger equipment to inject and mix without excavation. They also have a twin, 5 ft auger system powered and moved by a standard backhoe, hollow shaft auger drills into soil, and a controlled nozzle system. Millgard Environmental Corp. has the MecTool system which has been approved for solidification of 80,000 cubic yards in India, and a pilot test underwater in a Canadian province.

SCIENCE AND TECHNOLOGY NEEDS:

Debris which is buried underground, such as tree stumps, mechanical equipment, large concrete slabs, etc., will cause problems.

IMPLEMENTATION NEEDS:

Needs demonstration on trial site.

COMMENTS:

Evaluation complete.

EVALUATOR: Dave Tyson

Phone (208) 526-5443

FAX (208) 526-1998

REFERENCES:

Pete Shagan, 313-261-9760, Millgard Environmental (from VISITT database)

Rich Murray, 602-821-0409, In Situ Fixation Co (from VISITT database).

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.

OU 1-05, TSF-06; OU 2-05, TRA-15; OU 3-07, CPP-28, CPP-31, CPP-79; OU 3-08, CPP-27; OU 3-12, CPP-81, CPP-82; OU 3-13, CPP-39.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-03, WRRTF-01.; OU 1-04, LOFT-02.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-05, TSF-21; OU 1-06, TSF-07; OU 2-09, TRA-07; OU 3-08, CPP-45; OU 3-09, CPP-01, CPP-02, CPP-04, CPP-05, CPP-06, CPP-09; OU 5-12, PBF-08, PBF-10; OU 7-13, RWMC-04.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 1-06, LOFT-01; OU 3-11, CPP-45; OU 4-06, CFA-44.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

OU 3-08, CPP-35; OU 3-09, CPP-03, CPP-08, CPP-10, CPP-11, CPP-17, CPP-19, CPP-22; OU 3-11, CPP-58; OU 3-12, CPP-80.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-level radioactive, noncompactible; Mixed low-level radioactive, noncompactible, corrosive, metals; Hazardous, metals, organics.

Waste Form/Contaminants:

Soil, concrete, floor and asphalt/¹³⁷Cs, ¹³⁴Cs, ⁶⁰Co, ⁹⁰Sr, ¹³⁷Cs and ¹³⁴Cs at 200 mR/hr., Hg, mercuric nitrate, nitric acid, chromium, lead, and paint thinner.

SUBELEMENTS: Treatment - Thermal and Physical

ALTERNATIVES: Soil Washing

TECHNOLOGY: Soil Washing

STATUS: Research and development needed

Soil washing is a water based, volumetric reduction/waste minimization process, whereby hazardous contaminants are extracted and concentrated into a small residual portion of the original volume. The technology is well known and in common use in Europe. The process has been successfully demonstrated on mixed waste at the Oak Ridge National Laboratory Y-12 plant. Typical hazardous contaminant groups which can be effectively removed include petroleum and fuel residues, radionuclides, heavy metals, PCB, PCP, and pesticides.

SCIENCE AND TECHNOLOGY NEEDS:

Technology is most effective as a waste minimization/volume reduction process. For the process to be economically feasible, the contaminated material must consist of not more than 40% passing 63 microns. The contaminated soil should contain less than 20% by volume of solid organic material. Complex waste mixtures, such as metals with organics, make washing fluid formulation difficult.

IMPLEMENTATION NEEDS:

The major unit processes are: 1) a feed preparation unit where feedstock is tumbled and washed with high pressure water sprays in a rotating trommel screen; 2) an attrition scrubbing unit to remove surficial contaminants from individual sand grains; 3) a size classification/desliming/thickening unit to remove clays which are a primary host to the contaminants; 4) a gravity separation unit to remove solid organic materials or to separate high specific gravity contaminants which exist as discrete particles; 5) a clarification/water treatment unit to remove contaminants from the wash water for reuse; and 6) a dewatering unit to prepare the contaminant laden fines for the appropriate ultimate destruction or immobilization process.

COMMENTS:

Evaluation complete.

EVALUATOR: Greg Bala Phone (208) 526-8178

REFERENCES:

Vendor contacts: Bergmann USA
 Northwest Enviroservice

INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 4-05, CFA-17.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 1-06, LOFT-01; OU 7-08, RI/FS.

Unexploded naval ordnance.

OU 10-03, Ordnance Areas Including NODA.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Hazardous, organics, unexploded; Municipal, sanitary.

Waste Form/Contaminants:

Sludge, soil and solid/Fuel oil spills, diesel fuel, chloroform, TCE, toluene, and carbon tetrachloride.

SUBELEMENTS: Treatment - Thermal and Physical

ALTERNATIVES: Vacuum Vapor Extraction

TECHNOLOGY: Vacuum Vapor Extraction, In Situ

This technology removes subsurface organic contaminants by creating a vacuum in a well. The vapor and liquids are removed from the well and separated. The vapor may be released to the atmosphere after activated carbon and HEPA filtration.

STATUS: Accepted

Technology has been in use for approximately 10 years. It has been proven to be very effective on volatile and semi-volatile compounds having a Henry's constant of 0.0001 or greater. It is effective in all types of soils throughout a wide range of permeabilities. It can be combined with hot air injection, steam injection, electric soil heating or air sparging to enhance the volatility of the contaminants. Also, it can be combined with groundwater extraction from the same wells. Remediation time is between six months to three years. Secondary waste streams include offgas emissions and contaminated water. Estimated costs are between 10 to 100 dollars per ton.

SCIENCE AND TECHNOLOGY NEEDS:

Special concerns in remediating radioactive waste sites are minimization of exposure to workers and potential radioactive contamination containment. Remote handling capabilities need to be developed.

IMPLEMENTATION NEEDS:

Personnel requirements are greatest at startup and diminish with time. Once operational requirements are defined treatment can continue unsupervised with scheduled maintenance and system monitoring. Major components include extraction wells, manifold piping, vapor/liquid separator, activated carbon units or catalytic oxidizer, vacuum unit, manifold and instrumentation.

COMMENTS:

Completed.

EVALUATOR: Vickie Capps

Phone (208) 526-0485

FAX (208) 526-2354

REFERENCES:

Vendors contacted include:

Nuclear Remedial Technologies

Terra Vac

Kleinfelder

AWD Technologies.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.

OU 3-07, CPP-31; OU 3-08, CPP-27.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 4-05, CFA-17.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 3-13, CPP-48.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 4-09, CFA-10, CFA-26, CFA-42; OU-7-08, RI/FS.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Mixed low-level radioactive, noncompactible; Hazardous, metals, organics, corrosives; Radioactive, mixed radioactive, hazardous, organic, transuranic, Rocky Flats fire waste, Pu, fuel end boxes and petroleum.

Waste Form/Contaminants:

Concrete, sludge, soil, gravel; Debris - paper, rags, sweepings, vehicles, diatomaceous earth, wood, metal, and glass/⁹⁰Sr, ¹³⁷Cs, ⁶⁰Co, TCE, toluene, carbon tetrachloride Pu, mercuric nitrate, nitric acid, fuel oil, hydrofluoric acid, aluminum nitrate, lead, paint thinner, PCB spill, No. 2 diesel fuel, and chloroform.

SUBELEMENTS: Treatment - Thermal and Physical

ALTERNATIVES: Thermal Desorption

TECHNOLOGY: Rotary Kiln - Direct

This technology consists of wastes and auxiliary fuels being introduced into the high end of an inclined, rotary kiln. Ash residue and exhaust gases are collected at the low end of the kiln and may be further treated.

STATUS: Accepted

For nonradiologically contaminated hazardous waste and has been used at several EPA Superfund sites. The process is most amenable to hydrocarbon contaminated soils and sludges.

SCIENCE AND TECHNOLOGY NEEDS:

Development.

Test the equipment with hazardous and radioactive materials to ensure that permit requirements can be met. Feed system development for radioactive waste, waste characterization in support of production, secondary waste minimization, maintenance, and scrubber technology.

IMPLEMENTATION NEEDS:

Normal implementation needs.

Treatment costs should be fairly low, depending on the secondary offgas cleanup systems required. Wide Beach Superfund Site costs were approximately \$185.00/ton.

COMMENTS:

Evaluation Incomplete

EVALUATOR: Sylvester Losinski Phone (208) 526-5962
FAX (208) 526-2354

REFERENCES:**Vendor Contacts:**

Cannonie Environmental Services
IT Corporation
Chemical Waste Management

INEL PROBLEM SITES:

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 3-13, CPP-48.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 4-05, CFA-17.

Radioactive spill areas, spill migrations, and unconfined disposal sites.
OU 3-08, CPP-36.

Unexploded naval ordnance.
OU 10-03, Ordnance Areas Including NODA.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Hazardous, organics, corrosive, metals, unexploded ordnance; Radioactive, mixed radioactive, hazardous, organic, transuranic, Rocky Flats fire waste Pu, fuel end boxes; Mixed low-level radioactive, noncompactible, corrosive, and metals.

Waste Form/Contaminants:

Concrete, soil, sludge; Debris - paper, rags, sweepings, vehicles, diatomaceous earth, wood, metal, glass/⁹⁰Sr, ¹³⁷Cs, ¹³⁴Cs, ¹⁵⁴Eu, ⁶⁰Co, nitric acid, mercuric nitrate, TCE, toluene, carbon tetrachloride Pu, hydrofluoric acid, aluminum nitrate, lead, paint thinner, fuel oil, TNT, RDX, composition B, lithium, tetryl, picric acid, smokeless powder, old black powder, and ametol.

SUBELEMENTS: Treatment - Thermal and Physical

ALTERNATIVES: Thermal Desorption

TECHNOLOGY: Rotary Kiln - Indirect

This technology consists of wastes and auxiliary fuels being introduced into the high end of and inclined, rotary kiln. Ash residue and exhaust gases are collected at the low end of the kiln and may be further treated.

STATUS: Accepted

For nonradiologically contaminated hazardous waste, and has been used at several EPA Superfund sites. The process is most amenable to hydrocarbon contaminated soils and sludges.

SCIENCE AND TECHNOLOGY NEEDS:

Further development to test the equipment with hazardous and radioactive materials to ensure that permit requirements can be met. Feed system development for radioactive waste, waste

characterization in support of production, secondary waste minimization, maintenance, and scrubber technology.

IMPLEMENTATION NEEDS:

Normal implementation needs.

Treatment costs should be fairly low, depending on the secondary offgas cleanup systems required. Wide Beach Superfund Site costs were approximately \$185.00/ton.

COMMENTS:

Evaluation Incomplete

EVALUATOR: Sylvester Losinski Phone (208) 526-5962

FAX (208) 526-2354

REFERENCES:

Vendor Contacts:

Cannonie Environmental Services

IT Corporation

Chemical Waste Management

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.

OU 1-05, TSF-PM2A; OU 3-07, CPP-31; OU 3-08, CPP-27.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-03, TSF-38, WRRTF-01; OU 1-04, LOFT-02; OU 4-05, CFA-04.

Radioactive sumps, ponds, its, trenches, rubble piles, etc.

OU 1-06, TSF-07.

Nonradioactive spill areas, spill migrations, and underconfined disposal sites.

OU 1-06, TSF-08; OU 4-09, CFA-26, CFA-42; OU 7-08, RI/FS.

Radioactive spill areas, spill migrations, and unconfined disposal sites.

Landfills.

OU 4-12, CFA-02, CFA-03.

PROBLEM AREAS/CONTAMINANTS:

Waste Types:

Indeterminate; Low-level radioactive, noncompactible; Mixed low-level radioactive, noncompactible; Hazardous, organics, metals; Petroleum; Municipal - sanitary.

Waste Form/Contaminants:

Sediment, concrete, soil, gravel, petroleum; Debris - glass and plastics; Sludge/⁹⁰Sr, TCE, TCA, xylene in parts per billion, ⁶⁰Co, ¹³⁷Cs (1000pCi/g), ²³⁹Pu, ²⁴⁰Pu, (1pCi/g), ¹³⁴Cs, ¹⁵⁴Eu, ⁹⁰Sr (5pCi/g), metals, lead, chromium, mercuric nitrate, nitric acid, PCB spill, No. 2 diesel fuel; laboratory chemical, heavy hydrocarbons Pb, mercury, beryllium, and trichloroethane.

SUBELEMENTS: Treatment - Thermal and Physical

ALTERNATIVES: Thermal Desorption

TECHNOLOGY: Externally Fired Roaster (XTRAX)

STATUS: Accepted

For nonradiologically contaminated hazardous wastes. Process is under serious consideration for utilization in site remediation activities at INEL Pit 9. Utilized treatment technology for Resolve Superfund Site in Massachusetts, in which PCBs were removed from soil. Laboratory scale processing of mercury and uranium contaminated soil at Oak Ridge National Laboratory.

SCIENCE AND TECHNOLOGY NEEDS:

Design and demonstration of feed systems and treated waste handling systems. Separation system's design for waste specific offgas from roaster. Volatile metals such as mercury are carried over in the vapor phase.

IMPLEMENTATION NEEDS:

Normal implementation needs. Treatment costs should be fairly low, but will be strongly dependent on secondary treatment options, which are waste specific.

COMMENTS:

Evaluation Complete

EVALUATOR: Sylvester Losinski Phone (208) 526-5962
FAX (208) 526-2354

REFERENCES:

Vendor Contact: Chemical Waste Management, Inc.

INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38, TSF-03, WRRTF-01; OU 1-04, LOFT-02

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 3-08, CPP-15; OU 7-13, RI/FS

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 4-06, CFA-44

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Hazardous-organics, metals; Low-level radioactive-noncompactible; Radioactive, mixed radioactive, hazardous, organic, transuranic, Rocky Flats fire waste, Pu, fuel end boxes.

Waste Form/Contaminants:

Debris-glass, plastics, paper, rags, sweepings, vehicles, diatomaceous earth, wood and metal; soil; concrete/any metal or laboratory chemical; heavy hydrocarbons, Pb, lead and mercury, plutonium at low levels, kerosene and tributyl phosphates, ⁶⁰Co, TCE, toluene, carbon tetrachloride, Pu, lead, and paint thinner.

SUBELEMENTS: Thermal and Physical

ALTERNATIVES: Thermal desorption

TECHNOLOGY: Indirectly heated screw conveyor

Patented low temperature thermal treatment (LT3) process by Roy F. Weston, Inc., consisting of hollow flite screw conveyors heated by a working fluid in a closed loop heat transfer cycle.

Nominal working temperature of 580-degree F, throughput rate of 15,000 lbs./hr. of soil

containing 20% moisture and 1% organics. Working fluid temperature of 650-degree F.

Residence time at temperature for processing soil/waste controlled by variable speed drives and working fluid temperature.

Vapors drawn off by induced draft fan.

STATUS: Demonstration, testing and evaluation needed

Commercially available for nonradioactive treatment of volatile and semivolatile contaminated soils.

SCIENCE TECHNOLOGY NEEDS:

None.

Within the established envelope(s) of operation.

IMPLEMENTATION NEEDS:

Design modifications for radioactive environments and maintenance reliability validation via hot testing.

COMMENTS:

Should be readily adaptable to radioactive environments.

One of the lower cost alternatives for initial drying (moisture) of soil.

Pretreatment size reduction required to less than two (2) inches diameter nominal. Particle/chunk size limits heat transfer capability.

Volatization of semivolatiles (treatable quantity) is limited by the maximum safe working temperature of the heating fluid.

EVALUATOR: Sylvester Losinski

Phone (208) 526-5962

FAX (208) 526-2354

REFERENCES:

Description and information from "Thermal 1, Thermally Enhanced Volatization," Satellite Seminar, February 18, 1993, sponsored by Air and Waste Management Association.

INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 1-03, TSF-38, TSF-03, WRRTF-01; OU 1-04, LOFT-02

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 3-08, CPP-15; OU 7-13, RI/FS

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 4-06, CFA-44

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Hazardous-organics, metals; Low-level radioactive-noncompactible; Radioactive, mixed radioactive, hazardous, organic, transuranic, Rocky Flats fire waste, Pu, fuel end boxes.

Waste Form/Contaminants:

Debris-glass, plastics, paper, rags, sweepings, vehicles, diatomaceous earth, wood and metal; soil; concrete/any metal or laboratory chemical; heavy hydrocarbons, Pb, lead and mercury, plutonium at low levels, kerosene and tributyl phosphates, ⁶⁰Co, TCE, toluene, carbon tetrachloride, Pu, lead, and paint thinner.

SUBELEMENTS: Thermal and Physical

ALTERNATIVES: Thermal desorption

TECHNOLOGY: Anaerobic Thermal Processor

Patented anaerobic thermal processor (ATP) process by SoilTech ATP Systems, Inc., consisting 1) preheat zone, 2) retort zone, 3) combustion zone, and 4) cooling zone. Nominal working temperature of 500-degree F for preheat zone (indirect heating), 930-1150-degree F for retort zone (anaerobic distillation and removal of vapors), 1,400-degree F for combustion zone back to preheat zone. Equipment throughput rate of 5 tons/hr. mobile, 10 tons/hr. transportable, and 25 tons/hr. transportable. Vapors drawn off by induced draft fan.

STATUS: Demonstration, testing and evaluation needed

Commercially available for non-radioactive treatment of volatile, semi-volatile and PCB contaminated soils.

SCIENCE AND TECHNOLOGY NEEDS:

None.

Within the established envelope(s) of operation.

IMPLEMENTATION NEEDS:

Design modifications for radioactive environments and maintenance reliability validation via hot testing.

COMMENTS:

Moderate cost higher temperature thermal desorber.

Moderately complicated equipment potentially reducing operating envelopes and increasing operating complexities for radioactive environments.

Throughput rate limited by the moisture content of the soil.

Pretreatment size reduction required

Designed for treatment of PCB contaminated soils. Capability for recycling of lower temperature volatiles (petroleum) hydrocarbons.

EVALUATOR: Joanne Hillary

Phone (208) 526-5092

FAX (208) 526-2354

REFERENCES:

Description and information from "Thermal 1, Thermally Enhanced Volatization," Satellite Seminar, February 18, 1993, sponsored by Air and Waste Management Association.

INEL PROBLEM SITES:

Nonradioactive sumps, ponds, pits, trenches, rubble piles etc.

OU 4-05, CFA-17.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 4-09, CFA-10; OU 7-08, RI/FS.

Unexploded naval ordnance

OU 10-03, ordnance areas

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Low-Level radioactive, combustibles; Municipal - sanitary, refuse; Hazardous, organics; Nonhazardous, metal.

Waste Form/Contaminants:

Debris - paper and plastics/⁶⁰Co, ¹³⁷Cs, ¹³⁴Cs, ⁹⁰Sr, ¹⁵⁴Eu; Sludge; Fuel oil spills; Ordnance - TNT, RDX, Composition B, lithium, tetryl, picric acid, smokeless powder, old black powder, and amatol.

SUBELEMENT: Treatment - Thermal and Physical

ALTERNATIVE: Incineration

TECHNOLOGY: Controlled Air Incineration

This technology consists of incineration with the amount of oxygen in the incinerator being regulated to control the types of byproducts being formed.

STATUS: Accepted

Four DOE facilities have used controlled air incinerators to process low-level radioactive wastes. Some have been used for treatment of transuranic wastes. Recent advances have been made in control systems resulting in improved control of incinerator temperatures and exit oxygen concentrations

SCIENCE TECHNOLOGY NEEDS:

Specific wastes must be characterized and sized. Some may not be treated because of large noncombustible bulk or fusible residues. Further technology advances will likely be directed to improved hearth design, refractory improvements, feed system automation, and heat recovery from the exit gas stream.

IMPLEMENTATION NEEDS:

Normal implementation needs.

COMMENTS:

Evaluation Complete.

EVALUATOR: Sylvester Losinski Phone (208) 526-5962
FAX (208) 526-2354

REFERENCES:

Vendor Contacts:

Joy Energy Systems
Cleaver Brooks

INEL PROBLEM SITES:

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 7-13, RWMC-04.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.
OU 4-06, CFA-44.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.
OU 4-05, CFA-17.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Mixed low-level radioactive, metals; Radioactive, mixed radioactive, hazardous, organic, transuranic, Rocky Flats fire waste Pu, fuel end boxes; Hazardous, metals, and organics.

Waste Form/Contaminants:

Soil; Sludge, Debris - paper, rags, sweepings, vehicles, diatomaceous earth, wood, metal, and glass/⁶⁰Co, ¹³⁷Cs, chromium, TCE, toluene, carbon tetrachloride Pu, lead, paint thinner, and fuel oil spills.

SUBELEMENTS: Treatment - Thermal and Physical

ALTERNATIVES: Incineration

TECHNOLOGY: Rotary Kiln Incineration

This technology consists of wastes and auxiliary fuels being introduced into the high end of an inclined, rotating kiln. Ash residue and exhaust gases are collected at the low-end of the kiln and may be further treated.

STATUS: Accepted

Rocky Flats tested a 45 kg/h but it was never operated on a production basis due to problems associated with the facility that housed the unit. INEL tested a rotary kiln for thousands of hours with successful results. The INEL kiln was not operated with hazardous waste because of DOE permitting problems. Oak Ridge has treated low-level radioactive liquid wastes in a rotary kiln at 270 kg/h, but has not processed solid materials due to regulatory issues associated with disposal of ash.

SCIENCE AND TECHNOLOGY NEEDS:**Development.**

Test the equipment with hazardous and radioactive materials to ensure that permit requirements can be met. Feed system development for radioactive waste. Atomization and ultrafiltration

pretreatment of radioactive liquids. Waste characterization in support of production. Secondary waste minimization. Maintenance.
Scrubber technology.

IMPLEMENTATION NEEDS:

Normal implementation needs. Treatment costs should be fairly low, depending on the offgas cleanup systems required. Regulatory issues associated with disposal of ash and solids have not been adequately resolved. Costs for nonradioactive hazardous wastes are approximately \$180.00/ton.

COMMENTS:

Evaluation Complete.

EVALUATOR: Sylvester Losinski Phone (208) 526-5962
FAX (208) 526-2354

REFERENCES:**Vendor Contacts:**

Martin Marietta Energy Systems, ORNL
Fuller
Joy Energy Systems Inc.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.
OU 3-09, CPP-69.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.
OU 4-09, CFA-26, CFA-42. OU 7-08, RI/FS.

Unexploded naval ordnance.
OU 10-03, Ordnance Areas Including NODA.

Landfills.
OU 4-12, CFA-02, CFA-03.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Radioactive, mixed radioactive, hazardous - organic, transuranic, Rocky Flats fire waste Pu, and fuel end boxes; Low-level radioactive - liquid; Hazardous - organics; Petroleum; Nonhazardous - metal; Municipal - sanitary.

Waste Form/Contaminants:

Debris - paper, rags, sweepings, vehicles, diatomaceous earth, wood, metal, glass; Liquid, soil, gravel, sludge, ordnance; ^{137}Cs , ^{134}Cs , ^{60}Co , TCE, toluene, carbon tetrachloride Pu, PCB spill, No. 2 diesel fuel, chloroform, paint thinner, mercury, beryllium, and trichloroethane, TNT, RDX, composition B, lithium, tetryl, picric acid, smokeless powder, old black powder, and ametol.

SUBELEMENTS: Treatment - Thermal and Physical

ALTERNATIVES: Incineration

TECHNOLOGY: Liquid Injection Combustor

This technology consists of liquid waste being introduced into a combustion chamber using specially designed nozzles. Combustion gases are then cooled and treated to remove particles and neutralize acid gases. Effective operation requires finely atomized liquids.

STATUS: Accepted

Various units are commercially available. Units have been tested on hazardous materials. Units can dispose of any combustible liquid with a viscosity of less than 10,000 SSU including slurries.

SCIENCE AND TECHNOLOGY NEEDS:

Liquid injection combustors must still be qualified for use with radioactive materials.

IMPLEMENTATION NEEDS:

Normal implementation needs.

COMMENTS:

EVALUATOR: Sylvester Losinski Phone (208) 526-5962
FAX (208) 526-2354

REFERENCES:

Eg&G Idaho, Inc., "Environmental Technologies Information System," Computer Database, Developed October 1990 for DOE/ID.

H.M. Freeman, Editor, "Standard Handbook of Hazardous Waste Treatment and Disposal," New York: McGraw-Hill Book Company, 1989.

Yen-Hsiung Kiang, and A. A. Metry, "Hazardous Waste Processing Technology," Boston: Butterworth Publishers, 1982.

Hazardous Waste Remedial Actions Program, "An Assessment of Thermal Destruction of Energy Mixed Wastes," DOE/HWP-106-Vol. 1 and 2, August 1991.

INEL PROBLEM SITES:

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.
OU 4-09, CFA-26, CFA-42.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Petroleum; Hazardous, organics.

Waste Form/Contaminants:

Soil/No. 2 diesel fuel, fuel oil.

SUBELEMENTS: Treatment - Thermal and Physical

ALTERNATIVES: Incineration

TECHNOLOGY: Industrial Boiler

This technology consists of using water to fuel an industrial boiler.

STATUS: Accepted

For nonradioactive wastes.

SCIENCE AND TECHNOLOGY NEEDS:

If radioactive wastes are considered, significant work may be required to contain the radioactivity.

IMPLEMENTATION NEEDS:

Normal implementation needs.

COMMENTS:

Evaluation complete.

EVALUATOR: Sylvester Losinski Phone (208) 526-5962
FAX (208) 526-2354

REFERENCES:

Hazardous Waste Remedial Actions Program, "An Assessment of Thermal Destruction of Energy Mixed Wastes," DOE/HWP-106-Vol. 1 and 2, August 1991.

INEL PROBLEM SITES:

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.
OU 7-08, RI/FS.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Hazardous - organics; Nonhazardous - metal.

Waste Form/Contaminants:

Soil, ordnance/Chloroform, TCE, toluene, carbon tetrachloride, TNT, RDX, Composition B, Lithium, Tetryl, Picric Acid, Smokeless Powder, Old Black Powder, and Ametol.

SUBELEMENTS: Treatment - Thermal and Physical

ALTERNATIVES: Thermal Degradation

TECHNOLOGY: Wet Air Oxidation

This technology consists of heating an aqueous waste stream and compressed air and passing the stream through a reactor to oxidize dissolved organics.

STATUS: Research and development needed

This technology is operational, but specific applications have to be researched. Methods for treating halogenated species must be devised.

SCIENCE AND TECHNOLOGY NEEDS:

Develop methods for treating halogenated materials. Investigate behavior of radioactive materials.

IMPLEMENTATION NEEDS:

High pressure system hardware required. Wastewater would still require treatment for radionuclides.

COMMENTS:

Evaluation Incomplete

EVALUATOR: Sylvester Losinski Phone (208) 526-5962
FAX (208) 526-2354

REFERENCES:

Vendor Contacts:
Zimpro Inc.

INEL PROBLEM SITES:

Radioactive underground storage tanks, aboveground storage tanks, and associated soil.

OU 1-05, TAN V-1, TAN V-2, TAN V-3.

Nonradioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 4-05, CFA-17.

Radioactive sumps, ponds, pits, trenches, rubble piles, etc.

OU 7-13, RWMC-04.

Nonradioactive spill areas, spill migrations, and unconfined disposal sites.

OU 4-09, CFA-10; OU 7-08, RI/FS.

Unexploded naval ordnance.

OU 10-03, Ordnance Areas Including NODA.

Landfills.

OU 4-12, CFA-02, CFA-03.

PROBLEM AREAS/CONTAMINANTS:**Waste Types:**

Radioactive, mixed radioactive, hazardous, organic, transuranic, Rocky Flats fire waste Pu, and fuel end boxes; Nonhazardous - metal; Municipal - sanitary.

Waste Form/Contaminants:

Debris - paper, rags, sweepings, vehicles, diatomaceous earth, wood, metal, glass; Soil, gravel, ordnance, sludge/60Co, TCE, toluene, carbon tetrachloride Pu, PCB spill, chloroform, chromium, mercury, beryllium, and trichloroethane, TNT, RDX, composition B, lithium, tetryl, picric acid, smokeless powder, old black powder, and ametol.

SUBELEMENTS: Treatment - Thermal and Physical

ALTERNATIVES: Thermal Degradation

TECHNOLOGY: Supercritical Water Oxidation

This technology is an enhanced wet-air oxidation process with reaction conditions in the supercritical range of water yielding factor reactor rates and higher efficiencies than ordinary wet-air oxidation.

STATUS: Research and development

This is an emerging technology. No testing has been done on radioactive wastes. Bench-scale and pilot-scale tests have been performed on some hazardous wastes. The INEL is preparing for

a series of pilot-scale tests on surrogate radioactive wastes. The technology shows strong promise for treatment of oxidizable hazardous wastes, with demonstrated destruction efficiencies as high as 99.9999%. Can be operated in a closed process batch cycle, which could be extremely useful for treatment of radiologically contaminated wastes. Research work is currently being funded through the INEL for advancement of this technology.

SCIENCE/TECHNOLOGY NEEDS:

Testing must be performed to determine the behavior of radionuclides in the reactor. Specific waste streams must be pilot tested. Equipment corrosion problems must be solved. A better theoretical base must be established for chemical reactions in supercritical water.

IMPLEMENTATION NEEDS:

High pressure system hardware required. Wastewater would still require treatment for radionuclides.

COMMENTS:

Evaluation Incomplete

EVALUATOR: Sylvester Losinski Phone (208) 526-5962
FAX (208) 526-2354

REFERENCES:

Vendor Contacts:

Modell Development Corporation
Modar Inc.

5. CAPS AND BARRIERS

INEL PROBLEM SITES:

OU 1-05; OU 2-05; OU 3-07; OU 1-03; OU 1-04; OU 4-05; OU 1-06; OU 7-13; OU 3-09; OU 3-11; OU 4-12.

PROBLEM AREAS/CONTAMINANTS: Surface water migration into buried waste.

SUBELEMENTS: Caps and Barriers

ALTERNATIVES: Water balance cap

TECHNOLOGY: Caps

Capping of waste areas consists of placing a barrier over a site to prevent the infiltration of water into the waste from above. Many different barrier systems fall under the broad heading of caps. Caps may be as simple as sheet plastic held down by sand bags or as complex as multi-layered systems which include low permeability layers, drainage layers, vegetative layers, intruder protection layers etc.

STATUS: Accepted

Some capping systems have become fairly common, with numerous installations nationwide. Other systems are only in the developmental stages. Though caps are being designed and constructed, many aspects of the technology are still in demonstration or pre-demonstration stages.

The EPA published "Minimum Technology Guidance" documents for caps which outline performance standards and give recommended cross-sections of caps for hazardous waste closures. Many sites have been capped in accordance with the EPA guidance. Some of these caps have failed, and the EPA and the technical community is currently rethinking the technology in an effort to produce more dependable caps.

SCIENCE AND TECHNOLOGY NEEDS:

For caps with soil layers additional work needs to be performed in the area of desiccation of clays and the effect of desiccation on cap permeability. For geomembrane caps extensive materials testing and longevity testing is needed. A "water balance" cap approach is being developed for the arid west. Elements of the water balance approach may be applicable to humid areas, but more study is required.

IMPLEMENTATION NEEDS:**COMMENTS:**

EVALUATOR: Vaughn E. Halford

Phone (208) 526-6096

FAX (208) 526-6852

REFERENCES:

T. H. Smith, W. S. Roesener, and M. J. Jorgenson-Waters, EG&G Idaho Internal Report, EGG-WM-10728, "A Preliminary Evaluation of Alternative for Disposal of INEL Low-Level Waste and Low-Level Mixed Waste", July 1993.

INEL PROBLEM SITES:

OU 1-05; OU 2-05; OU 3-07; OU 1-03; OU 1-04; OU 4-05; OU 1-06; OU 3-09; OU 7-13;
OU 3-11; OU 4-12;

PROBLEM AREAS/CONTAMINANTS:

Surface water migration into buried waste

SUBLEMENTS: Caps and Barriers

ALTERNATIVES: Water balance cap

TECHNOLOGY: Water balance cap

Capping of waste areas consists of placing a barrier over a site to prevent the infiltration of water into the waste from above. The water balance cap is a technology developed at Hanford for arid sites. The technology is based on the principle that a fine-grained soil layer overlying a coarse-grained soil layer will hold water in capillary voids until saturated before the water will drain into the coarse-grained soil. If the fine-grained soil layer is of adequate thickness to hold all of the available moisture, no water will flow into the lower coarse-grained layer. Eventually, the water will be evaporated from the fine-grained layer. Native plants assist the upper soil layer in drying by the evapotranspiration of water.

STATUS: Demonstration, testing, and evaluation needed

Demonstrations of this technology are underway at Hanford. There are full-scale test plots under construction and evaluation. Numerous studies of various aspects of barrier development in arid climates have been performed at Hanford.

SCIENCE AND TECHNOLOGY NEEDS:

None identified.

IMPLEMENTATION NEEDS:

The use of a Technological concept should be based in part, on the determination that the concept provides the necessary degree of waste isolation.

COMMENTS:

None.

EVALUATOR: Vaughn E. Halford

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FAX (208) 526-6852

REFERENCES:

Wing, N.R., L.L. Cadwell, G.W. Gee, 1992. Project Plan:
Permanent Isolation Surface Barrier System - Prototype Design.
Richland, Washington.
Author: Bill Barton/615-576-0519.

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INDEX

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- CPP-19, **IB**:16; **II**:73, 127, 204, 251; **III**:11, 29, 35, 41, 50, 52, 67, 69, 71, 85, 87, 91, 97, 102, 104, 110, 112, 119, 129, 146, 150, 153, 157, 159, 177, 214, 220, 229, 245, 271, 290
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