INEL-94/0253

Mixed Waste Integrated Program Logic Diagram

John Mayberry
Michael O'Brien
Mark Rudin
James Ferguson
John McFee
Stella Stelle

Published November 1994

Idaho National Engineering Laboratory
[redacted]
Idaho Falls, Idaho 83415

Prepared for the
U.S. Department of Energy

Under DOE Idaho Operations Office
Contract DE-AC07-[redacted]

94ID13223

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Mixed Waste Integrated Program

Logic Diagram

November 30, 1994

prepared by:
John Mayberry - SAIC, Idaho Falls, ID
Michael O'Brien - University of Arizona, Tucson, AZ
Mark Rudin - University of Nevada, Las Vegas, NV
James Ferguson - Lockheed Idaho Technologies Company, Idaho Falls, ID
John McFee - I.T. Corp., Albq., NM
Stella Stelle - SAIC, Idaho Falls, ID

Mixed Waste Integrated Program
Logic diagram
Table of Contents

WASTE STREAMS

DISPOSAL

ABSTRACT

The Mixed Waste Integrated Program Logic Diagram was developed to provide technical alternative for mixed wastes projects for the Office of Technology Development's Mixed Waste Integrated Program (MWIP). Technical solutions in the areas of characterization, treatment, and disposal were matched to a select number of U.S. Department of Energy (DOE) treatability groups represented by waste streams found in the Mixed Waste Inventory Report (MWIR).

SUMMARY

The Mixed Waste Integrated Program Logic Diagram was developed to provide information to support the Mixed Waste Integrated Program (MWIP) and its technology evaluation teams during the selection of technology development activities for Fiscal Years 95, 96, and 97. In addition, the logic diagram effort:

- Identifies pressing technology development needs, addressable by the MWIP, which will enable EM-30 to meet legal deadlines imposed by the Federal Facilities Compliance Act.

- Establishes a mechanism to increase communication between EM-50 and EM-30.

- Provides those responsible with remediating Department of Energy low-level mixed waste, or low-level mixed waste similar to that found at DOE sites, a tool for evaluating characterization, treatment and disposal options.

- Addresses two Idaho National Engineering Laboratory specific waste streams representative of one or more of the MWIP Treatability Groups.

Thirteen mixed waste treatability groups and example waste streams were identified for inclusion in the Mixed Waste Integrated Program Logic Diagram. These treatability groups/waste streams were chosen in consultation with representatives from DOE HQ (EM-50, EM-30) and representatives from the MWIP. A major criteria used in selecting example waste streams for inclusion was a broad representation of the 20 matrix categories as identified in the Mixed Waste Inventory Report.

Mixed Waste Integrated Program

Logic Diagram

Fernald
Salt Sludge, Chloride
Treatment Technologies

Mixed Waste Integrated Program Logic Diagram

Name: Salt Sludge, Chloride **MWIR#:** FM-W249 **Subelement:** Treatment

Matrix: Chloride Salts / 3151 **Site:** Fernald

Waste Stream

Waste Stream Description

This waste consists of a chloride salt sludge produced by a Salt-Oil Furnace.

Problems Presented by this Waste Stream

The estimated density of the waste stream (3711 kg/m³) seems high, base on the waste description (primarily sludge) and also inconsistent with other data reported (1964 kg/m³).

High salt content within the waste stream may limit waste treatment technology options. Since this waste stream contains chlorides, vitrification may not be an appropriate treatment because of the difficulty of glass formation in the presence of chlorides. The chloride salts may also increase the volatility of the chromium constituent in the waste.

Treatability Group

Radiological Contaminants:
This waste is classified as a Beta-Gamma emitter and as a contact-handled waste with < 10 nCi/g of alpha-emitting radionuclides.

MLLW-CH
U-(unspecified)
U-235

Contaminants:
This waste stream is suspected to be contaminated with the toxic heavy metal, chromium, and may be corrosive, due to the salt content. The following EPA-regulated wastes are suspected to be contained in the waste stream:

D007: Chromium

Matrix:
This waste matrix is a chloride salt sludge.

Mixed Waste Integrated Program Logic Diagram

Name: Salt Sludge, Chloride **MWIR#:** FM-W249 **Subelement:** Treatment

Matrix: Chloride Salts / 3151 **Site:** Fernald

Alternative/Technology

THERMAL TREATMENT

ALTERNATIVE - Vitrification

TECHNOLOGY - Joule Heated Melter
Refractory-lined reactor in which a pool of glass is maintained molten by joule heating. Waste is introduced into the glass matrix. Since the waste loading is expected to be low, it may require the addition of significant volumes of glassification agents.

Status

Treatability studies are being performed on a similar type of waste type. Demonstration of the technology's applicability to this waste stream will be required.

Subsystems required
- Waste feed system
- Glass additive feed system
- Molten glass handling system
- Offgas collection/treatment system, including scrubber and particulate filters

Projected performance
- Need to tightly control melt chemistry complicates operation
- Addition of glass formers to maintain viscosity limits otherwise excellent volume reduction
- Highly stable glass final waste form

Science and Technology Needs

Technology must be demonstrated to assess its applicability to this waste stream, including the operation of required subsystems.

Implementation Analysis

High power requirements. This technology will be commercially available for waste applications within 2 years, and is currently in use for highly specialized applications in the DOE system. Unit operational costs and life cycle costs fall in the mid range of this group of technologies. The large numbers of subsystems required and need to carefully control melt chemistry make this technology relatively complicated and labor-intensive. The effect of the chloride salts present in this waste stream must be investigated for this technology. There is a medium development risk, when compared to the other thermal technologies.

Input Waste Stream Characterization Information Needed

Characterization requirements will include estimates of chloride and chromium content and the composition/concentration of salts present in this waste stream (see concentration of sodium, potassium, sulfates, nitrates, chlorides, and chromium in the characterization subelement beginning on page A-5).

Waste Streams Produced

Stabilized glass can be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or as TRU waste) (see stabilized glass disposal options beginning on page N-1).

Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page A-6).

Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page A-6).

Empty containers can be disposed of as LLW (see empty containers disposal options beginning on page N-1).

Alternative/Technology (continued)

CHEMICAL TREATMENT
Although chemical treatment could be applicable to this waste stream, it was dismissed because of the inevitable generation of a large amount of secondary wastes that would also require treatment. The production of secondary wastes is due to the

Mixed Waste Integrated Program Logic Diagram

Name: Salt Sludge, Chloride **MWIR#:** FM-W249 **Subelement:** Treatment

Matrix: Chloride Salts / 3151 **Site:** Fernald

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
high-salt content of the sludge. Excessive dilution of the waste media would be required to enable chemical treatment.			
PHYSICAL TREATMENT			
ALTERNATIVE - Stabilization	CbC is in early stages for development by the DOE for usage on this type of waste streams. Subsystems required Waste feed system Ingredients feed system Shredder for combustibles and small metal pieces Projected performance Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input Waste Stream Characterization Information Needed The concentration of sodium, potassium, sulfates, nitrates, and chlorides (see concentration of sodium, potassium, sulfates, nitrates, and chlorides in the characterization subelement beginning on page A-6). Waste Streams Produced A solidified waste form that requires LLW disposal (see solid waste forms disposal options beginning on page N-1).
Chemically-bonded Ceramics (CbC) Chemically-bonded ceramic waste forms are produced by mixing the wastes and inorganic oxide binders together. The mixture is then processed at ambient and near ambient temperatures, promoting chemical reactions that bond the waste and the inorganic oxides into a dense ceramic material.			
Polyethylene Polyethylene is an inert thermoplastic material that can be processed at low temperatures. Polyethylene binder and dry waste material are fed through separate calibrated volumetric or loss-in-weight feeders to an extruder. The materials are then thoroughly mixed, heated to a molten condition, and extruded into a suitable mold. On cooling, the mixture forms a solid monolithic waste form. No chemical reaction is required for solidification.	Polyethylene is being developed by the DOE for usage on these types of waste streams. Polyethylene has been demonstrated on scrubber residues. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and the compatibility of the process with the actual waste streams. The technology needs development for the treatment of shredded particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input Waste Stream Characterization Information Needed The percent soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of sodium, potassium, sulfates, nitrates, and chlorides in the characterization subelement beginning on page A-6). Waste Streams Produced A solidified waste form that requires LLW disposal (see solid waste forms disposal options beginning on page N-1).
Sulfur Polymer Cement (SPC) Sulfur Polymer Cement is composed of 95% sulfur. It melts at approximately 110 to 120 C and is particularly valuable in the immobilization combustibles and small metal pieces.	SPC is being developed by the DOE for usage within this type of waste streams at INEL. SPC has been demonstrated on ash. SPC is not compatible with waste streams containing high concentrations of nitrates. Subsystems required Waste feed system	Technology must be demonstrated on this waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input Waste Stream Characterization Information Needed The concentration of sodium, potassium, sulfates, nitrates, and chlorides (see concentration of sodium,

Mixed Waste Integrated Program Logic Diagram

Name: Salt Sludge, Chloride **MWIR#:** FM-W249 **Subelement:** Treatment
Matrix: Chloride Salts / 3151 **Site:** Fernald

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Sulfur Polymer Cement (SPC) (continued)	Ingredients feed system Shredder for combustibles and small metal pieces Projected performance Expected to produce a suitable final waste form for disposal		potassium, sulfates, nitrates, and chlorides in the characterization subelement beginning on page A-6). Waste Streams Produced A solidified waste form that requires LLW disposal (see solid waste forms disposal options beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: Salt Sludge, Chloride **MWIR#:** FM-W249 **Subelement:** Treatment

Matrix: Chloride Salts / 3151 **Site:** Fernald

Secondary Waste Stream	Treatability Group
Bottom ash Flyash Offgas particulate filters Scrubber residue	Radiological Constituents: This waste is classified as a Beta-Gamma emitter and as a contact-handled waste with < 10 nCi/g of alpha-emitting radionuclides. Contaminants: This waste stream is contaminated with the toxic heavy metal, chromium. Matrix: The waste consists of ash, residues, and filters.

Mixed Waste Integrated Program

Logic Diagram

Fernald
Salt Sludge, Chloride
Characterization Technologies

Mixed Waste Integrated Program Logic Diagram

Name: Salt Sludge, Chloride **MWIR#:** FM-W249 **Subelement:** Characterization

Matrix: Chloride Salts / 3151 **Site:** Fernald

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Concentration of soluble sodium, potassium, sulfates, nitrates, and chlorides.	Alternative/Technology Atomic Absorption (AA), Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.0). EPA has approved the following methods for determining the concentration of potassium and sodium in wastes: EPA Method 258.1 - potassium (detection limit 0.01 mg/L) EPA Method 273.1 - sodium (detection limit 0.002 mg/L)	None, with proper sample preparation. This is a well-developed technology.	Method(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required.
	Alternative/Technology Ion Chromatography (IC)	Accepted by EPA and industry. Ion Chromatography (EPA Method 300.0) is able to quickly and accurately determine anions in solution to ppm or ppb concentrations. In order to use IC for solids, an extraction method outlined in EPA Method 300.0 must be performed. Additional separation techniques may be needed to further separate ionic species. EPA Method 300.0 - chloride (detection limit 0.02 mg/L) EPA Method 300.0 - nitrate (detection limit 0.002-0.004 mg/L) EPA Method 300.0 - sulfate (detection limit 0.02 mg/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available.
	Alternative/Technology Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES' primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to mini-	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).

Mixed Waste Integrated Program Logic Diagram

Name: Salt Sludge, Chloride **MWIR#:** FM-W249 **Subelement:** Characterization

Matrix: Chloride Salts / 3151 **Site:** Fernald

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	ICP-AES (continued)	mize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a consistent flow of sample to the instrument via the use of a peristolic pump, and/or by the use of the standard additions method. EPA Method 200.7 - potassium (detection limit 0.3 mg/L) EPA Method 200.7 - sodium (detection limit 0.03 mg/L)		
	Alternative/Technology Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8).	None with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s) available.

Mixed Waste Integrated Program

Logic Diagram

Hanford
183-H Solar Basin Waste
Treatment Technologies

Mixed Waste Integrated Program Logic Diagram

Name: 183-H Solar Basin Waste **MWIR#:** 986 **Subelement:** Treatment

Matrix: Pond Sludges / 3122 **Site:** Hanford

Waste Stream

Waste Stream Description

This waste stream consists of halogenated and non-halogenated solvents, cyanides, ignitable solids, and toxic heavy metals including: chromium.

Problems Presented by Waste Stream

Wastes are a result of the D&D cleanup activities of the H-183 Solar Basin. Waste sludges and liquid were solidified using Sorbond LPC-II (product of American Colloid Company). Sorbond is a pozzalonic cement with a polymer additive. Actual physical characteristics of this waste stream are needed to determine the waste feed system requirements. LDR treatment requirements for the listed waste codes are deactivation, chemical oxidation, or incineration. All must be followed by stabilization. These treatments will be sufficient to eliminate the toxic characteristic component of the wastes.

The characterization forces some assumptions in order to select technology options. It is assumed that the cyanides that were placed into the basin were not spent (due to the use of RCRA "P" waste codes). Due to the presence of chromium above 5.0 ppm in some EP Toxic Statistical Calculation Results, D007 should also be included. This waste has a very high salt content, primarily sodium salts.

The D001 waste code should be verified through analysis. The physical characterization of the solidified waste materials should be performed. Due to the RCRA "P" waste code identification, containers must be treated/rinsed prior to any disposal.

Treatability Group

Radiological Constituents:
This waste is classified as contact-handled with 10 - 100 nCi/g of alpha contamination.

Contaminants:
This waste stream is suspected to be contaminated with halogenated and non-halogenated solvents, Cyanides, ignitable solids, and toxic heavy metals including: chromium. The following EPA regulated wastes are suspected to be contained within the waste stream:

D001: Unlisted hazardous waste characteristic of ignitability
P029: Copper cyanide
P030: Cyanide (soluble salts)
P098: Potassium cyanide
P106: Sodium cyanide
P120: Vanadium oxide
U123: Formic acid

Matrix:
This waste consists of pond sludges.

Mixed Waste Integrated Program Logic Diagram

Name: 183-H Solar Basin Waste **MWIR#:** 986 **Subelement:** Treatment

Matrix: Pond Sludges / 3122 **Site:** Hanford

Alternative/Technology

CHEMICAL TREATMENT

Not applicable to this waste form. The sludge has been solidified using Sorbond LPC-II. Sorbond LPC-II is a polymer used to macro-encapsulate the wastes. Because of the encapsulated nature of the contaminants within the waste matrix, it is doubtful that complete treatment via a chemical process could be performed upon this waste stream. This is due to an inability to completely de-capsulate and free the contaminants within the waste matrix. If the contaminants within the waste matrix are not free to interact with chemical reagents, the required chemical reactions (and thus waste treatment) will not occur.

THERMAL TREATMENT - ALTERNATIVE - Incineration

Rotary Kiln

A cylindrical refractory-lined shell mounted on a slight incline; rotation of the kiln moves the non-containerized waste through the shell enhancing mixing. A high-temperature secondary combustion chamber is also utilized to complete organic compound destruction.

The high temperature may volatilize certain metals (such as arsenic, mercury, selenium, cadmium, and lead) which would require the subsequent capture of these metals in the incinerator offgas. The incinerator offgases would be subsequently cooled in order to allow these oxidized metals (or compounds) to condense prior to being entrained via a particulate removal device. High levels of sodium within the waste may cause a condition of low-temperature melting with this waste. The refractory material will need to be carefully selected for its compatibility with the waste. The high nitrate content could result in a high NOx emission.

Status

Accepted by industry.
This technology has been approved by EPA as the BDAT for organics, as well as cyanide. The DOE operates a rotary kiln for treatment of liquid LLW.

Subsystems required
- Feed pretreatment crusher, shredder, or slurry system (as needed based on physical characteristics)
- Secondary combustion chamber
- Large offgas treatment system, including off gas scrubber, and particulate filters
- Ash handling system
- Stabilization system for treatment residuals

Projected performance
- Good organic and cyanide destruction
- Rotating kiln seals are questionable for performing contamination control
- Post-treatment stabilization of ash residuals using cement is currently in wide use
- Long-term leaching performance is suspect
- Volume reduction is moderate
- Alternate stabilization techniques are available for better long-term performance

Science and Technology Needs

Better characterization of the waste stream is needed to determine the extent of volatilization of other waste constituents. Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems. Demonstration of the compatibility of refractory materials with this waste stream. Determination of melting point range.

Determination of NOx gas emission potential.

Implementation Analysis

Normal implementation needs. Treatment residue will require treatment/stabilization prior to disposal. The rotary kiln incineration technology is commercially available and currently used within the commercial sector. The technology is currently in use within the DOE sector for non-cemented sludge wastes. The required subsystems as described above are currently commercially available. The moving parts and large number of subsystems required, make this technology relatively complicated and labor intensive. Since rotary kilns cannot be routinely cycled (on-off), large waste backlogs are necessary to justify implementation.

Input waste stream characterization information needed

Characterization requirements may include the identification of volatile metals in the waste stream (see volatile metals in the characterization subelement beginning on page B-11).

Waste streams produced

Bottom ash that requires stabilization (see bottom ash under secondary waste streams beginning on page B-8).

Flyash that requires stabilization (see flyash under

Mixed Waste Integrated Program Logic Diagram

Name: 183-H Solar Basin Waste **MWIR#:** 986 **Subelement:** Treatment

Matrix: Pond Sludges / 3122 **Site:** Hanford

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Rotary Kiln (continued)			secondary waste streams beginning on page B-8). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page B-8). Empty containers can be disposed of as LLW (see empty containers disposal options beginning on page N-1). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page B-8).
ALTERNATIVE - Vitrification Slagging Kiln Cylindrical refractory-lined shell mounted on a slight incline; rotation of the kiln moves the non-containerized waste through the shell, enhancing mixing. Operation similar to rotary kiln except it is operated at a higher temperature with the addition of glassification agents. A high-temperature secondary combustion chamber is also required to complete the organic compound destruction. The high-temperature may volatilize certain metals (such as arsenic, mercury, selenium, cadmium, and lead) which will require the subsequent capture of the volatile metals in the incinerator offgas. The incinerator offgases would be subsequently cooled in order to allow these metals (or compounds) to condense prior to being entrained via a particulate removal device. High sodium levels may cause a condition of low-temperature melting with this waste. The refractory material will need to be carefully selected to determine its compatibility with the waste.	Accepted by industry. This technology has been approved by EPA as the BDAT for organics, as well as cyanide. Slagging kilns are more widely used in Europe than the US. Subsystems required Feed pretreatment crusher, shredder, or slurry system (as needed based on physical characteristics) Secondary combustion chamber Large offgas treatment system, including offgas scrubber, and particulate filters Glass additive feed system Molten glass handling system Stabilization system for treatment residuals Projected performance Good organic and cyanide destruction Rotating kiln seals are questionable for reliable contamination control Good leaching resistance performance of the glassified product	Better characterization of the waste stream to determine the extent of volatilization of other waste constituents. Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems. Demonstration of refractory waste compatibility. Additional treatability studies to determine optimum additive/waste mix.	Normal implementation needs. Slagging kiln incineration technology is commercially available. The required subsystems, as described above are currently commercially available. The moving parts and the large number of subsystems required, make this technology relatively complicated and labor intensive. Input waste stream characterization information needed Characterization requirements may include the identification of volatile metals in the waste stream. (see volatile metals in the characterization subelement beginning on page B-11). Waste streams produced Slag may be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see slag disposal options beginning on page N-1). Flyash that requires stabilization (see flyash under secondary waste streams beginning on page B-8). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page B-8). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page B-8). Empty containers can be disposed of as LLW (see empty containers disposal options beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: 183-H Solar Basin Waste **MWIR#:** 986 **Subelement:** Treatment

Matrix: Pond Sludges / 3122 **Site:** Hanford

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Joule Heated Melter Refractory-lined reactor in which a pool of glass is maintained molten via joule heating; size-reduced waste is introduced into the glass pool and dissolved into the glass matrix. High-temperatures may volatilize certain metals (such as arsenic, mercury, selenium, cadmium, and lead) require subsequent capture of the volatile metals within the incinerator offgas. The vitrifier offgases would be subsequently cooled in order to allow these metals (or compounds) to condense prior to being entrained via a particulate removal device. Sodium and sulfate content will require the addition of significant volumes of glassification agents.	DOE has developed vitrification for HLW applications. Demonstration on LLW sludges is in progress. Subsystems required Waste feed pretreatment crusher, shredder or slurry system to reduce waste size (as appropriate) Waste feed system Glass additive feed system Molten glass handling system Secondary combustion chamber Small offgas treatment system, including acid gas scrubber, metal recovery system, and particulate filter Projected performance Good organic destruction requires reduction pretreatment or extended periods in the melt Need to tightly control melt chemistry which can complicate the operation Offgas system flyash can be processed through the melter Addition of glass formers necessary to maintain desired viscosity limits volume reduction Glass final waste form possesses good leaching resistance.	Technology must be demonstrated to assess its applicability to the treatment of this waste stream, including the operation of the required subsystems	High power requirements. This technology will be commercially available for waste applications within 2 years, and is currently in use for highly specialized applications in the DOE system. Unit operational costs and life cycle costs fall in the mid-range of this group of technologies. The large number of subsystems required and the need to carefully control melt chemistry make this technology relatively complicated and labor-intensive. The physical characteristics of this waste stream are a good match for this technology. This technology has a medium development risk compared to the other thermal technologies. <u>Input waste stream characterization information needed</u> Characterization requirements include the identification of volatile metals and vitrification qualities due to salt content of this waste stream. Salts may include NaCl, KCl, along with sulfates, nitrates, and some fluorides (see volatile metals and salt content in the characterization subelement beginning on page B-11). <u>Waste streams produced</u> Stabilized glass can be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see stabilized glass disposal options beginning on page N-1). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page B-8). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page B-8). Empty containers can be disposed of as LLW (see empty containers disposal options beginning on page N-1).
Plasma Arc Furnace Refractory-lined chamber into which unopened, containerized waste is introduced and melted in the high-temperature arc of a plasma torch. High-temperature volatilizes certain metals (such as arsenic, mercury, selenium, cadmium, and lead) require the subsequent capture of the metals in the offgas. The offgases would be subsequently	Large scale proof-of-principle pilot batch unit has been demonstrated. Upgrades to the pilot plant to implement a continuous waste feed system and melt removal system is currently in the design phase. Subsystems required Waste feed system (with size reduction for oversized containers)	Treatability tests are needed to identify the NOx emission potential. Technology must be demonstrated to assess its applicability to the treatment of this waste stream, including the operation of the required subsystems Treatability tests are needed to identify if glass formers are required.	Very high power requirements. This technology is the furthest from commercial availability, but should be proven in 3-5 years. Unit operational costs are comparable to a joule melter. Minimal feed pretreatment requirements make this technology simple and non-labor intensive. This system is suited to process this waste stream without pretreatment. This has the highest development risk of all of the thermal tech-

Mixed Waste Integrated Program Logic Diagram

Name: 183-H Solar Basin Waste **MWIR#:** 986 **Subelement:** Treatment

Matrix: Pond Sludges / 3122 **Site:** Hanford

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Plasma Arc Furnace (continued) cooled in order to allow these metals (or compounds) to condense prior to being entrained via a particulate removal device. A secondary combustion chamber for treatment of organics is commonly included.	Glass additive feed system (as needed) Molten material handling system Secondary combustion chamber Offgas treatment system, including acid gas scrubber and particulate filters Projected performance Highest temperature range, good organic destruction with no pretreatment Slag and metal final waste forms are leach resistant Offgas system particulate filters and flyash can be processed through the furnace		nologies. The high salt content of the waste may dictate the need for glass formers. NOx emissions may require additional controls. Input waste stream characterization information needed Characterization requirements may include the identification of volatile metals within the waste stream (see volatile metals in the characterization subelement beginning on page B-11). Waste streams produced Slag may be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see slag disposal options beginning on page N-1). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page B-8). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page B-8).
Microwave Melter A process that uses microwave energy to solidify wastes within the metal container either in a batch or continuous feed mode. High-temperature melt occurs at between 1800° - 2600° F, resulting in a glassy-monolithic waste material. Due to the temperatures created in this process certain metals (such as arsenic, mercury, selenium, cadmium, and lead) may volatilize. These volatilized metals need to be condensed prior to being entrained via a particulate removal device. Typical volume reductions through this process may be as high as 60 to 80%. Materials would require drying prior to this treatment. Stabilization additives may be required to create a final waste form.	A large scale non-radioactive pilot plant has been operated. Subsystems required Waste feed system Molten-material handling system (as applicable) Secondary combustion chamber Stabilization additive feed system (as needed) Projected performance High-temperature range with good organic destruction Highly stable glass waste form Reduced handling requirements and generation of secondary wastes through in-drum processing	Study of potential container melt and corrosion problems required. Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems. Demonstration of vitrification capabilities is required, and the identification of the potential for excessive NOx emissions generation is needed.	Very high power requirements. This technology is not yet commercially available, but should be proven in 2 - 4 years. Unit operational costs are high due to low throughput comparable to a joule melter or a plasma arc furnace. Minimal subsystem requirements make this technology extremely simple and non-labor intensive. This technology has a medium development risk of all of the thermal technologies. Input waste stream characterization information needed Characterization requirements may include the identification of volatile metals in the waste stream. (see volatile metals in the characterization subelement beginning on page B-11). Corrosive nature of ash during micro-waving (see salt content in the characterization subelement beginning on page B-11). Waste streams produced Slag may be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contami-

Mixed Waste Integrated Program Logic Diagram

Name: 183-H Solar Basin Waste **MWIR#:** 986 **Subelement:** Treatment

Matrix: Pond Sludges / 3122 **Site:** Hanford

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Microwave Melter (continued)			nated LLW, or TRU waste) (see slag disposal options beginning on page N-1). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page B-8). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page B-8).

Mixed Waste Integrated Program Logic Diagram

Name: 183-H Solar Basin Waste **MWIR#:** 986 **Subelement:** Treatment
Matrix: Pond Sludges / 3122 **Site:** Hanford

Secondary Waste Stream	Treatability Group
Bottom ash Flyash Offgas particulate filters Scrubber residue	**Radiological Constituents:** This waste may be classified as a waste containing 10-100 nCi/g of alpha-emitting radionuclides. However the waste may possibly be classified as TRU waste, if the radionuclides in the waste feed become concentrated within the products generated by the treatment process. **Contaminants:** This waste stream is contaminated with toxic heavy metals including chromium. The following EPA-regulated wastes are suspected to be contained within the waste stream: P029: Copper cyanide P030: Cyanide (soluble salts) P098: Potassium cyanide P106: Sodium cyanide P120: Vanadium oxide U123: Formic acid **Matrix:** This waste consists of filters, ash, and residues.

Mixed Waste Integrated Program Logic Diagram

Name: 183-H Solar Basin Waste **MWIR#:** 986 **Subelement:** Treatment

Matrix: Pond Sludges / 3122 **Site:** Hanford

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
ALTERNATIVE - Solidification / Stabilization			
Polyethylene Polyethylene is an inert thermoplastic material that can be processed at low temperatures. Polyethylene binder and dry waste material are fed through separate calibrated volumetric or loss-in-weight feeders to an extruder. The materials are then thoroughly mixed, heated to a molten condition, and extruded into a suitable mold. On cooling, the mixture forms a solid monolithic waste form. No chemical reaction is required for solidification.	Polyethylene is being developed by DOE for use in similar types of waste streams. Polyethylene has been demonstrated on scrubber residues. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to be a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual waste constituents. The technology needs development on the shredded particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see solid waste forms disposal beginning on page N-1).
Sulfur Polymer Cement (SPC) Sulfur Polymer Cement is composed of 95% sulfur. It melts at approximately 110 to 120°C and is particularly applicable to the immobilization of toxic metals and treatment of incinerator ash.	SPC is being developed by DOE for use in these types of waste streams. SPC has been demonstrated on ash. SPC is not compatible with wastes containing a high nitrate loading. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to be a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual waste constituents. The technology needs development on the shredded particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see solid waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: 183-H Solar Basin Waste **MWIR#:** 986 **Subelement:** Treatment

Matrix: Pond Sludges / 3122 **Site:** Hanford

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Chemically-Bonded Ceramics (CBC) Chemically-bonded ceramic waste forms are produced by mixing the wastes and inorganic oxide binders together. The mixture is then processed at ambient and near ambient temperatures, promoting chemical reactions that bond the waste and the inorganic oxides into a dense ceramic material.	CBC is in early stages for development by DOE for use in these types of waste streams. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to be a suitable final waste form for disposal.	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual constituents contained within the waste stream. The technology needs development on the shredded particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see solid waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program

Logic Diagram

Hanford
183-H Solar Basin Waste
Characterization Technologies

Mixed Waste Integrated Program Logic Diagram

Name: 183-H Solar Basin Waste **MWIR#:** 986 **Subelement:** Characterization

Matrix: Pond Sludges / 3122 **Site:** Hanford

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Volatile metals (such as arsenic, mercury, cadmium, selenium, and lead).	Alternative/Technology Atomic Absorption (AA), Furnace Technique	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following methods for determining the concentration of volatile metals in wastes: EPA Method 206.2 - arsenic (detection limit 1 ug/L) EPA Method 213.2 - cadmium (detection limit 0.1 ug/L) EPA Method 270.2 - selenium (detection limit 2 ug/L) EPA Method 239.2 - lead (detection limit 1 ug/L)	None, with proper sample preparation.	Method(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Arsenic and selenium analysis can suffer from severe nonspecific absorption and light scattering by matrix components during atomization due to their low analytical wavelengths. Simultaneous background corrections must be made for all metals to avoid erroneously high results.
	Alternative/Technology Atomic Absorption (AA), Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following methods for determining the concentration of volatile metals in wastes: EPA Method 213.1 - cadmium (detection limit 0.005 mg/L) EPA Method 239.1 - lead (detection limit 0.1 mg/L)	None, with proper sample preparation.	Method(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required. For concentrations of cadmium below 0.02 mg/L, the furnace procedure (EPA Method 213.2) is recommended. For concentrations of lead below 0.2 mg/L, the furnace procedure (EPA Method 239.2) is recommended.
	Alternative/Technology Atomic Absorption, Cold-Vapor	Accepted. Samples must be converted to suitable solutions for analysis. EPA has approved the following methods for determining the total mercury (inorganic and organic) in solid wastes: EPA Method 245.5 - mercury (detection limit .0002 mg/L)	None. All samples must be subject to an appropriate dissolution step prior to analysis.	Method(s) available. Potassium permanganate is added to eliminate possible interference from sulfide. Wastes high in chloride require additional permanganate. Certain volatile organic absorb at the wavelength of mercury vapor (253.7-nm). A preliminary run without reagents should determine if this type of interference is present.
	Alternative/Technology Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES's primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as	None, with proper sample preparation. This is a well-developed technology.	Method(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false ana-

Mixed Waste Integrated Program Logic Diagram

Name: 183-H Solar Basin Waste **MWIR#:** 986 **Subelement:** Characterization

Matrix: Pond Sludges / 3122 **Site:** Hanford

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Volatile metals (continued)	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES) (continued)	acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a consistent flow of sample to the instrument via the use of a peristolic pump, and/or by the use of the standard additions method. EPA Method 200.7 - arsenic (detection limit 0.008 mg/L) EPA Method 200.7 - mercury (detection limit 0.02 mg/L) EPA Method 200.7 - cadmium (detection limit 0.001 mg/L) EPA Method 200.7 - selenium (detection limit 0.02 mg/L) EPA Method 200.7 - lead (detection limit 0.01 mg/L)		lyte concentrations may arise - see Table 2, EPA Method 200.7).
	→ Alternative/Technology Inductively-Coupled Plasma Mass Spectrometry (ICP-MS) →	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8). EPA Method 200.8 - arsenic (detection limit 0.9 ug/L) EPA Method 200.8 - cadmium (detection limit 0.1 ug/L) EPA Method 200.8 - selenium (detection limit 5 ug/L) EPA Method 200.8 - lead (detection limit 0.08 ug/L) →	None with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation. →	Method(s) available.

Mixed Waste Integrated Program Logic Diagram

Name: 183-H Solar Basin Waste **MWIR#:** 986 **Subelement:** Characterization

Matrix: Pond Sludges / 3122 **Site:** Hanford

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Salt content (salts may include NaCl, KCl, along with sulfates, nitrates, and some fluorides).	Alternative/Technology Atomic Absorption, Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following methods for determining the concentration of potassium and sodium in wastes: EPA Method 258.1 - potassium (detection limit 0.01 mg/L) EPA Method 273.1 - sodium (detection limit 0.002 mg/L)	None, with proper sample preparation. This is a well-developed technology.	Method(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required.
	Alternative/Technology Ion Chromatography (IC)	Accepted by EPA and industry. Ion Chromatography (EPA Method 300.0) is able to quickly and accurately determine anions in solution to ppm or ppb concentrations. In order to use IC for solids, an extraction method outlined in EPA Method 300.0 must be performed. Additional separation techniques may be needed to further separate ionic species. EPA Method 300.0 - fluoride (detection limit 0.01 mg/L) EPA Method 300.0 - chloride (detection limit 0.02 mg/L) EPA Method 300.0 - nitrate (detection limit 0.002-0.004 mg/L) EPA Method 300.0 - sulfate (detection limit 0.02 mg/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available. Estimated capital costs: $30K.
	Alternative/Technology Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES's primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements	None, with proper sample preparation. This is a well-developed technology.	Method(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).

Mixed Waste Integrated Program Logic Diagram

Name: 183-H Solar Basin Waste **MWIR#:** 986 **Subelement:** Characterization

Matrix: Pond Sludges / 3122 **Site:** Hanford

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Alternative/Technology Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES) (continued)	and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a consistent flow of sample to the instrument via the use of a peristolic pump, and/or by the use of the standard additions method. EPA Method 200.7 - potassium (detection limit 0.3 mg/L) EPA Method 200.7 - sodium (detection limit 0.03 mg/L)		
	Alternative/Technology Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8).	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s) available.

Mixed Waste Integrated Program

Logic Diagram

Hanford
TC Metal Inorganic Solid Debris
Treatment Technologies

Mixed Waste Integrated Program Logic Diagram

Name: TC Metal Inorganic Solid Debris **MWIR#:** RL-W027 **Subelement:** Treatment

Matrix: Predominantly Metal Debris / 5190 **Site:** Hanford

Waste Stream

Waste Stream Description

This waste consists of solid debris (mainly crushed light tubes) generated from clean-up and maintenance activities of various processes and support operations within a Plutonium Finishing Plant. It is stored within a carbon-steel box.

Problems Presented by Waste Stream

The waste is contaminated with cadmium, mercury, and PCB's. The PCB's within the waste have been estimated to be >500 ppm. The waste characteristics information indicates that PCBs are present in 100% of the waste stream. Therefore sorting/segregation of PCBs has been ruled out as an option. Since the concentration of the PCBs is more than 50 ppm, the waste has to be incinerated in compliance with TSCA regulations.

Treatability Group

Radiological Constituents:
This waste may be classified as a waste containing 10-100 nCi/g of alpha-emitting radionuclides. However the waste may be classified as TRU waste, if the radionuclides in the waste feed become concentrated within the products generated by the treatment process.

MLLW-CH
Alpha-emitter (10-100 nCi/g)
Cs-137
Ba-137
Sr-90
Y-90
Mixed Fission Products
H-3

Contaminants:
This waste stream is contaminated with cadmium, mercury, and PCBs. The following EPA regulated wastes are suspected to be contained within the waste stream:

D006: Cadmium
D009: Mercury
PCBs (estimated to be >500 ppm)

Matrix:
This waste matrix consists of a crushed solid (metal, glass, combustible) debris waste that is 20-30% combustible. BTU (BTUs/lb of mass) = 3000.

Mixed Waste Integrated Program Logic Diagram

Name: TC Metal Inorganic Solid Debris **MWIR#:** RL-W027 **Subelement:** Treatment

Matrix: Predominantly Metal Debris / 5190 **Site:** Hanford

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
THERMAL TREATMENT ALTERNATIVE - Retorting / Roasting followed by Incineration of Residues Retorting/roasting Low-temperature thermal unit in which mercury is vaporized for subsequent capture within the offgas. Options include desorber units (that are externally heated kilns) while other constituents are evacuated via batch waste systems. Volatilization of the other waste constituents is lower than in an incinerator, due to the lower process temperatures. The roaster offgases would be cooled to condense mercury and mercury compounds prior to capture within the offgas control device. A secondary combustion chamber is required for treatment of any volatile organics. The treated waste residue contains a large amount of carbon. The behavior of PCBs at 400°C will determine their final form after the mercury desorption process. If all of the PCBs are volatilized as light organics and pass through the condenser, the offgas can be sent direcly to a secondary combustion chamber. If there are remaining PCBs in the solid residue, they must be incinerated (Refer to Incineration Alternative). Since the mercury retorting/roasting process is performed at a temperature considerably lower than the boiling point of cadmium, it is expected that the cadmium will remain in the solid residues after the completion of the mercury retorting/roasting process. If any cadmium escapes with the offgas, it is expected to be captured during offgas treatment.	Accepted by industry. The EPA has approved this technology as the BDAT for high-mercury nonwastewaters. Subsystems required Feed pretreatment shredder for large items (as applicable) Small offgas treatment system, including offgas scrubber, mercury scrubber, and particulate filters Secondary combustion system (for treatment of volatilized organics) Solid residue handling system Mercury treatment system such as amalgamation Stabilization system for treatment residuals. Projected performance Good organic destruction in secondary combustion Post-treatment stabilization of incinerator ash residues using cement is currently in wide use Long-term leaching performance is suspect Volume reduction is moderate Residual fixed carbon may impede solidification	Better characterization of waste stream to determine extent of volatilization of other waste constituents and whether the waste requires mixing during treatment, (to enable the exposure of all mercury-contaminated materials to the unit's processing temperatures). Determination of solidification requirements for roasted waste materials and the appropriate solidification agent to be used. Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems.	Normal implementation needs. Captured mercury and treatment residue will require treatment/stabilization prior to disposal. This technology and its subsystems are commercially available and are currently in use in the commercial sector but the large number of subsystems required make this technology relatively complicated and labor intensive. <u>Input waste stream characterization information needed</u> No specific characterization requirements identified for this waste stream. <u>Waste streams produced</u> Bottom ash that requires stabilization (see bottom ash under secondary waste streams beginning on page C-7). Flyash that requires stabilization (see flyash under secondary waste streams beginning on page C-7). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page C-7). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page C-7). Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1). Mercury offgas (see mercury offgas under secondary waste streams beginning on page C-10). An amalgamate mercury that can be disposed of as RCRA LLW (see solidified waste forms disposal beginning on page N-1).
ALTERNATIVE - Incineration Rotary Kiln Cylindrical refractory-lined shell mounted on a slight incline; rotation of the kiln moves the noncontainerized waste through, while enhancing mixing. A high-temperature secondary combustion chamber is required to complete organic destruction. Cadmium that has volatilized and mercury that has not been recovered by the retorting/roasting unit, require subsequent capture in	Accepted by industry. This technology is BDAT for organics and metal contaminated nonwastewaters. The DOE is operating a rotary kiln in LLW service and post-treatment stabilization of ash residuals using cement is currently in use. Subsystems required Feed pretreatment shredder for large items (may not be necessary based on the waste stream	Better characterization of the waste stream to determine the extent of vaporization of other waste constituents. Demonstration of metal condensing process from the incineration offgas and subsequent capture of cadmium would be required.	Normal implementation needs. Captured metals and treatment residue will require treatment/stabilization prior to disposal. Rotary kiln incineration technology is commercially available, is currently in use, and planned for use within the DOE system. The required subsystems, as described above, (except for the metal condensation and collection system) are commercially available. The moving parts and large number of subsystems required, make this technolo-

Mixed Waste Integrated Program Logic Diagram

Name: TC Metal Inorganic Solid Debris **MWIR#:** RL-W027 **Subelement:** Treatment
Matrix: Predominantly Metal Debris / 5190 **Site:** Hanford

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Rotary Kiln (continued) the incinerator offgas. The offgases would be cooled to allow the cadmium in the offgas to condense out and be captured in an offgas particulate removal system (typically a HEPA filter).	description) Feed system Secondary combustion chamber Large offgas treatment system, including acid gas scrubber, metal removal system, and particulate filters Ash handling system Projected performance Good organic destruction Rotating kiln seals questionable for contamination control Posttreatment stabilization of ash residuals using cement is currently in wide use; long-term leaching performance is suspect; volume reduction is minimum; alternate stabilization techniques possible for better long-term performance		gy relatively complicated and labor intensive. Input Waste Stream Characterization Information Needed Characterization requirements may include determination of the extent to which volatile metals (e.g., cadmium) are present in this waste stream (see volatile metals in the characterization subelement beginning on page C-12). Waste Streams Produced Bottom ash that requires stabilization (see bottom ash under secondary waste streams beginning on page C-7). Flyash that requires stabilization (see flyash under secondary waste streams beginning on page C-7). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page C-7). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page C-7). Mercury contaminated offgas (see mercury offgas under secondary waste stream beginning on page C-10).
ALTERNATIVE - Vitrification			
Plasma Arc Furnace/Centrifugal Plasma Arc Furnace A typical plasma arc furnace uses a fixed refractory-lined chamber into which unopened, containerized waste is introduced and melted in the presence of a plasma torch. A centrifugal plasma arc furnace also melts the waste with a plasma torch but uses a rotating chamber for better treatment of particulates present in the waste. If this waste stream is found to contain a significant percentage of particulates, a centrifugal plasma arc may be more suitable. High-temperature volatilization of cadmium and mercury require their subsequent capture in the incinerator offgas. A secondary combustion chamber for destruction of PCBs will be required. The incinerator offgases would be subsequently cooled in order to allow condensation of metals prior to their capture in the offgas particulate removal system.	Large scale pilot demonstration complete. A radioactive waste bench scale system is under construction. Subsystems required Waste feed system Molten material handling system Offgas treatment system, including acid gas scrubber and particulate filters for capture of cadmium and any mercury remaining from the mercury bakeout process Projected performance Highest temperature range, good organic destruction with no pretreatment Maximum volume reduction Highly stable slag and metal final waste forms Offgas system particulate filters and flyash can be processed through the furnace	Technology must be demonstrated on this waste stream, including operation of required subsystems.	Very high power requirements. This technology is far from commercial availability, but should be proven in 3-5 years. Unit operational costs are comparable to costs associated with a joule melter. Minimal feed preparation requirements make this the simplest of the thermal treatment options. It requires no segregation of the various components of this waste stream. Highest development risk of the thermal technologies. Input waste stream characterization information needed Characterization requirements may include the identification of volatile metals in this waste stream (see volatile metals in the characterization subelement beginning on page C-12). Waste streams produced Slag may be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see slag disposal begin-

Mixed Waste Integrated Program Logic Diagram

Name: TC Metal Inorganic Solid Debris **MWIR#:** RL-W027 **Subelement:** Treatment

Matrix: Predominantly Metal Debris / 5190 **Site:** Hanford

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Plasma Arc Furnace/Centrifugal Plasma Arc Furnace (Continued)			ning on page N-1). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page C-7). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page C-7). Mercury offgas (see mercury offgas under secondary waste streams beginning on page C-10).
CHEMICAL TREATMENT No chemical technologies were found to be appropriate treatment options for the waste stream due to the inability to adequately sort/segregate the wastes.			
PHYSICAL TREATMENT Physical treatment via stabilization is applicable to waste streams classified as debris per the EPA debris rule. To qualify as 'debris', more than 50 percent of the waste stream by volume must meet the EPA definition of debris. Since the waste stream already contains PCBs, it is possible that the stabilization of debris under the RCRA regulations may not be an adequate treatment, because the PCBs may have still have to be destroyed under TSCA regulations.			
ALTERNATIVE - Stabilization			
Sulfur Polymer Cement (SPC) Sulfur Polymer Cement is composed of 95% sulfur. It melts at approximately 110 to 120°C and is particularly valuable in the immobilization of combustibles and small metal pieces.	SPC is being developed by the DOE for usage within this type of waste streams at INEL. SPC has been demonstrated on ash. SPC is not compatible with waste streams containing high nitrates. Subsystems required Waste feed system Ingredients feed system Shredder for combustibles and small metal pieces Projected performance Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input Waste Stream Characterization Information Needed The concentration of sodium, potassium, sulfates, nitrates, and chlorides (see concentration of soluble salts in the characterization subelement beginning on page C-12). Waste Streams Produced A solidified waste form that requires RCRA LLW disposal (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: TC Metal Inorganic Solid Debris **MWIR#:** RL-W027 **Subelement:** Treatment

Matrix: Predominantly Metal Debris / 5190 **Site:** Hanford

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Chemically-bonded Ceramics (CbC) Chemically-bonded ceramic waste forms are produced by mixing the wastes and inorganic oxide binders together. The mixture is then processed at ambient and near ambient temperatures, promoting chemical reactions that bond the waste and the inorganic oxides into a dense ceramic material.	CbC is in early stages for development by the DOE for usage on this type of waste streams. Subsystems required Waste feed system Ingredients feed system Shredder for combustibles and small metal pieces Projected performance Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input Waste Stream Characterization Information Needed The concentration of sodium, potassium, sulfates, nitrates, and chlorides (see concentration of soluble salts in the characterization subelement beginning on page C-12). Waste Streams Produced A solidified waste form that requires RCRA LLW disposal (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: TC Metal Inorganic Solid Debris **MWIR#:** RL-W027 **Subelement:** Treatment

Matrix: Predominantly Metal Debris / 5190 **Site:** Hanford

Secondary Waste Stream	Treatability Group
Bottom ash Flyash Scrubber residue Offgas particulate filters Carbon filters Mercury salts	Radiological Constituents: This waste may be classified as a waste containing 10-100 nCi/g of alpha-emitting radionuclides. However the waste may be classified as TRU waste, if the radionuclides in the waste feed become concentrated within the products generated by the treatment process. MLLW-CH Alpha-emitter (10-100 nCi/g) Cs-137 Ba-137 Sr-90 Y-90 Mixed Fission Products H-3 Contaminants: This waste stream is contaminated with toxic metals including mercury and cadmium. The following EPA-regulated wastes are suspected to be contained within the waste stream. D009: Mercury D006: Cadmium Matrix: This matrix is ash, residues, filters, and mercury salts.

Mixed Waste Integrated Program Logic Diagram

Name: TC Metal Inorganic Solid Debris **MWIR#:** RL-W027 **Subelement:** Treatment

Matrix: Predominantly Metal Debris / 5190 **Site:** Hanford

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
ALTERNATIVE: Solidification/Stabilization			
Polyethylene Polyethylene is an inert thermoplastic material that can be processed at low temperatures. Polyethylene binder and dry waste material are fed through separate calibrated volumetric or loss-in-weight feeders to an extruder. The materials are then thoroughly mixed, heated to a molten condition, and extruded into a suitable mold. On cooling, the mixture forms a solid monolithic waste form. No chemical reaction is required for solidification.	Polyethylene is being developed by the DOE for usage on these types of waste streams. Polyethylene has been demonstrated on scrubber residues. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and the compatibility of the process with the actual waste streams. The technology needs development for the treatment of particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input Waste Stream Characterization Information Needed</u> The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salts in the characterization subelement beginning on page C-12). <u>Waste Streams Produced</u> A solidified waste form that requires RCRA LLW disposal (see solidified waste forms disposal beginning on page N-1).
Sulfur Polymer Cement (SPC) Sulfur Polymer Cement is composed of 95% sulfur. It melts at approximately 110 to 120 C and is particularly valuable in the immobilization of toxic metals and treatment of incinerator ash.	SPC is being developed by the DOE for usage within these types of waste streams. SPC has been demonstrated on ash. SPC is not compatible with waste streams containing high nitrates. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and the processes' compatibility with the actual waste stream constituents. The technology needs development for treatment of particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input Waste Stream Characterization Information Needed</u> The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salts in the characterization subelement beginning on page C-12). <u>Waste Streams Produced</u> A solidified waste form that requires RCRA LLW disposal (see solidified waste forms disposal beginning on page N-1).
Chemically-bonded Ceramics (CbC) Chemically-bonded ceramic waste forms are produced by mixing the wastes and inorganic oxide binders together. The mixture is then processed at ambient and near ambient temperatures, promoting chemical reactions that bond the waste and the inorganic oxides into a dense ceramic material.	CbC is in early stages for development by the DOE for usage on these types of waste streams. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated for this waste stream to ensure stabilization of toxic constituents and the processes' compatibility with the actual waste stream constituents. The technology needs development for the treatment of particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input Waste Stream Characterization Information Needed</u> The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salts in the characterization subelement beginning on page C-12).

Mixed Waste Integrated Program Logic Diagram

Name: TC Metal Inorganic Solid Debris **MWIR#:** RL-W027 **Subelement:** Treatment
Matrix: Predominantly Metal Debris / 5190 **Site:** Hanford

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Chemically-bonded Ceramics (CbC) (continued)			<u>Waste Streams Produced</u> A solidified waste form that requires RCRA LLW disposal (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: TC Metal Inorganic Solid Debris **MWIR#:** RL-W027 **Subelement:** Treatment

Matrix: Predominantly Metal Debris / 5190 **Site:** Hanford

Secondary Waste Stream	Treatability Group
Mercury offgas	**Radiological Constituents:** This waste may be classified as a waste containing 10-100 nCi/g of alpha-emitting radionuclides. However the waste may be classified as TRU waste, if the radionuclides in the waste feed become concentrated within the products generated by the treatment process. MLLW-CH Alpha-emitter (10-100 nCi/g) Cs-137 Ba-137 Sr-90 Y-90 Mixed Fission Products H-3 **Contaminants:** This waste stream is contaminated with toxic metals including mercury and cadmium. The following EPA-regulated wastes are suspected to be contained within the waste stream. D009: Mercury D006: Cadmium **Matrix:** This waste consists of an offgas stream.

Mixed Waste Integrated Program Logic Diagram

Name: TC Metal Inorganic Solid Debris **MWIR#:** RL-W027 **Subelement:** Treatment

Matrix: Predominantly Metal Debris / 5190 **Site:** Hanford

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
ALTERNATIVE - Offgas Mercury Removal Wet Sodium Hypochlorite or Chelating Agent/Cupric Chloride Injection; Chemical Oxidation; Chemical Reduction; Amalgamation of Mercury The capture rate of mercury in the offgas, utilizing only a wet caustic scrubbing process, may not be sufficient. If the concentration of the mercury in the waste is high, additional steps to remove mercury from the offgas may be necessary. Subjecting the offgas to a wet sodium hypochlorite or chelating agent/cupric chloride injection during the wet scrubbing process and/or subjecting the offgas to a carbon absorption, following the wet scrubbing process will enable a greater capture rate of mercury. Mercury-contaminated wet blowdown liquids will require chemical treatments such as chemical oxidation (to destroy the chelating agent if it is used), chemical reduction of toxic metals, and/or amalgamation of mercury (depending on the concentration of mercury and other metals contained within the blowdown). The slurry will then be dehydrated down to a sludge and treated via stabilization.	Accepted by industry. Subsystems required Feed pretreatment in treatment of volatile mercury System for mercury removal from carbon (if encapsulation of charcoal with mercury is not acceptable for disposal) Mercury treatment system such as amalgamation or chemical oxidation Projected performance High mercury removal efficiency at low cost Effective at removing trace quantities of other contaminants Simple to operate and maintain	Improvements in the atomization process to improve mass transfer effectiveness. Demonstration of the technology on the specific thermal technology under the same flue-gas conditions. Development of a treatment for proper disposal of the residue.	Normal implementation needs. The technology is simple, but control and handling of the sodium sulfide requires care to prevent emission of sulfide fumes. <u>Input Waste Stream Characterization Information Needed</u> Concentrations levels of mercury in the waste (see volatile metals in the characterization subelement beginning on page C-12). <u>Waste Streams Produced</u> Mercury contaminated carbon filters that require stabilization (see carbon filters under secondary waste stream beginning on page C-7). Mercury salts contaminated with radionuclides that require stabilization (see mercury salts under secondary waste stream beginning on page C-7).

Mixed Waste Integrated Program

Logic Diagram

Hanford
TC Metal Inorganic Solid Debris
Characterization Technologies

Mixed Waste Integrated Program Logic Diagram

Name: TC Metal Inorganic Solid Debris **MWIR#:** RL-W027 **Subelement:** Characterization

Matrix: Predominantly Metal Debris / 5190 **Site:** Hanford

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
PCB	Gas Chromatography/Mass Spectrometry (GC/MS)	Accepted by EPA. Gas chromatography-mass spectrometry (GC-MS) is a technique which provides separation of volatile and semi-volatile organic molecules by gas chromatography and detection by mass spectrometry. Utilizes the separation characteristics of various chromatographic columns, qualitative and quantitative data are obtained by correlating masses detected with the elution times. EPA Method 680 - PCBs in soil/sediment by GCMS.	Technology is applicable as is. Benefit would be derived from faster chromatography to shorten analysis time.	Method(s) available. Mature technology.
Volatile metals (such as mercury and cadmium).	Atomic Absorption (AA), Furnace Technique	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.0). EPA has approved the following methods for determining the concentration of volatile metals in wastes: EPA Method 213.2 - cadmium (detection limit 0.1 ug/L)	None, with proper sample preparation.	Method(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Arsenic and selenium analysis can suffer from severe non-specific absorption and light scattering by matrix components during atomization due to their low analytical wavelengths. Simultaneous background corrections must be made for all metals to avoid erroneously high results.
	Atomic Absorption (AA), Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.0). EPA has approved the following methods for determining the concentration of volatile metals in wastes: EPA Method 213.1 - cadmium (detection limit 0.005 mg/L)	None, with proper sample preparation.	Method(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required. For concentrations of cadmium below 0.02 mg/L, the furnace procedure (EPA Method 213.2) is recommended. For concentrations of lead below 0.2 mg/L, the furnace procedure (EPA Method 239.2) is recommended.
	Atomic Absorption, Cold-Vapor	Accepted. Samples must be converted to suitable solutions for analysis. EPA has approved the following methods for determining the total mercury (inorganic and organic) in solid wastes: EPA Method 245.5 - mercury (detection limit .0002 mg/L)	None. All samples must be subject to an appropriate dissolution step prior to analysis.	Method(s) available. Potassium permanganate is added to eliminate possible interference from sulfide. Wastes high in chloride require additional permanganate. Certain volatile organic absorb at the wavelength of mercury vapor (253.7-nm). A preliminary run without reagents should determine if this type of interference is present.

Mixed Waste Integrated Program Logic Diagram

Name: TC Metal Inorganic Solid Debris **MWIR#:** RL-W027 **Subelement:** Characterization

Matrix: Predominantly Metal Debris / 5190 **Site:** Hanford

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a consistent flow of sample to the instrument via the use of a peristolic pump, and/or by the use of the standard additions method. EPA Method 200.7 - mercury (detection limit 0.02 mg/L) EPA Method 200.7 - cadmium (detection limit 0.001 mg/L)	None, with proper sample preparation. This is a well-developed technology.	Method(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).
	Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8). EPA Method 200.8 - cadmium (detection limit 0.1 ug/L)	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s) available.
Concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides).	Alternative/Technology Atomic Absorption (AA), Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.0). EPA has approved the	None, with proper sample preparation. This is a well-developed technology.	Method(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific

Mixed Waste Integrated Program Logic Diagram

Name: TC Metal Inorganic Solid Debris **MWIR#:** RL-W027 **Subelement:** Characterization

Matrix: Predominantly Metal Debris / 5190 **Site:** Hanford

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
		following methods for determining the concentration of potassium and sodium in wastes: EPA Method 258.1 - potassium (detection limit 0.01 mg/L) EPA Method 273.1 - sodium (detection limit 0.002 mg/L)		absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required.
	Alternative/Technology Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES' primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a consistent flow of sample to the instrument via the use of a peristolic pump, and/or by the use of the standard additions method. EPA Method 200.7 - potassium (detection limit 0.3 mg/L) EPA Method 200.7 - sodium (detection limit 0.03 mg/L)	None, with proper sample preparation. This is a well-developed technology.	Method(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).
	Alternative/Technology Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8).	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s) available.

Mixed Waste Integrated Program

Logic Diagram

Idaho National Engineering Laboratory
Cemented Sludge
Treatment Technologies

Mixed Waste Integrated Program Logic Diagram

Name: Cemented Sludge **MWIR#:** IN-W157 **Subelement:** Treatment

Matrix: Solidified Process Residues / 3150 **Site:** Idaho National Engineering Laboratory

Waste Stream

Waste Stream Description

Cemented Sludges at the Idaho National Engineering Laboratory.

This waste stream consists of cemented liquid wastes from paint strippers, degreasers, and cleaning solvents. This waste is generated by removal from processing tanks that collected liquid effluents from floor drains. Waste stream is no longer generated.

Problems Presented by Waste Stream

LDR treatment requirements for contaminants with listed waste codes are incineration followed by stabilization. This treatment will also be sufficient for the treatment of the toxic characteristic components. Waste information defines three separate waste streams; a special setups waste (1237 drums); high-level acid (901 drums); and high-level caustic (1486 drums). This does not account for the current total number of drums listed (4497), nor the 20 - 112 ft3 boxes (possibly 4'x4'x7'). Two types of solidification agents have been identified as having been used; portland cement and Florico absorbent (aluminum-magnesium-iron silicate clay). The material is packaged in plastic bags and inserted into steel drums containing plastic liners. External to the waste materials themselves Oil-Dry or Vermiculite were used within the drum to absorb any liquids that might not solidify and could potentially leak.

The solidified nature of the waste presents a significant problem for treatment. To destroy the organics by incineration would require size reduction by shredding or grinding to expose all of the organics to the required temperatures. Because the waste has been cemented inside drums, it will be very difficult to separate the waste from the metal container, plastic liner, and plastic bagging for treatment. Reslurrying of the unsolidified portion of this waste material may be the safest method for handling this waste stream. To further complicate treatment, the waste was sometimes cemented inside 1/2 gallon wide mouth polyethylene bottles then placed inside the drum liner of a 55 gallon drum. The presence of plastics impedes the process of shredding or grinding for separation. Even then, sintering of the exterior of larger waste chunks may trap organics inside without destruction and heavy metals without complete stabilization. Insuring complete destruction would probably require melting of all material to release and destroy all of the organics and to stabilize all of the heavy metals. Separation of the metal from the rest of the materials, required for some thermal processes, will be difficult after shredding with the plastics. It is questionable, based on current information whether or not the waste contained within any of these drums is actually classified as TRU.

Treatability Group

Radiological Constituents:
This waste is classified as contact-handled with10-100 nCi/g of alpha-contamination.

Contaminants:
This waste stream is contaminated with toxic organics and metals. The following EPA-regulated wastes are suspected to be contained within the waste stream:

- D002:Unlisted hazardous waste characteristic of corrosivity
- D007:Chromium
- D008:Lead
- F001:Halogenated solvents used for degreasing
- F002:Halogenated solvents and mixtures
- F003:Non-halogenated solvents

Matrix:
This waste consists of solidified sludges and particulates.

Mixed Waste Integrated Program Logic Diagram

Name: Cemented Sludge **MWIR#:** IN-W157 **Subelement:** Treatment

Matrix: Solidified Process Residues / 3150 **Site:** Idaho National Engineering Laboratory

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
CHEMICAL TREATMENT Not applicable to this waste stream, because of the encapsulated nature of the contaminants within the waste stream. It is doubtful that complete treatment via a chemical process could be performed upon this waste stream, due to inability to completely de-capsulate and free the contaminants within the waste matrix. If the contaminants within the waste matrix are not free to interact with chemical reagents, the required chemical reactions (and thus waste treatment) will not occur.			
THERMAL TREATMENT			
ALTERNATIVE: Incineration			
Rotary Kiln Cylindrical refractory-lined shell mounted on a slight incline; rotation of the kiln moves the non-containerized, size-reduced waste and container through while enhancing mixing. A secondary combustion chamber commonly follows the kiln to ensure complete organic destruction. The presence of portland cement used in solidification of some of this waste stream may cause calcination, resulting in high dust formation.	Accepted by industry. DOE is operating a rotary kiln in LLW services. Subsystems required Waste shredder or grinder Waste and container fines feed system Slurry feed system Secondary combustion chamber Large offgas treatment system, including dry offgas scrubber and particulate filter Ash handling system Stabilization system for final waste form Projected performance Good organic destruction Rotating kiln seals questionable for contamination control Stabilization posttreatment using cement is currently in wide use; volume reduction is not expected to occur with this waste.	Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems. Determination of physical waste characteristics will be needed. Immobilization techniques must be selected and demonstrated. The long-term leaching performance of this stabilized waste would need to be demonstrated.	Difficult implementation needs due to the combined waste types. Treatment residue will require stabilization prior to disposal. The rotary kiln incineration technology is commercially available and currently used within the commercial sector. The technology is currently in use within the DOE sector for non-cemented sludge wastes. The required subsystems as mentioned above are currently commercially available. Operational cost per unit throughput is lowest of all the technologies, but life cycle costs are high. The moving parts and large number of subsystems required make this technology relatively complicated and labor intensive. The solidified, non-combustible nature of this waste stream is not a good match for this technology. Lowest development risk of all of the thermal technologies. The varied composition of the wastes are expected to present materials of construction and design problems. <u>Input waste stream characterization information needed</u> Heat of combustion and alkali metal (sodium and potassium) content (see alkali metal in the characterization subelement beginning on page D-9). <u>Waste streams produced</u> Bottom ash that requires stabilization (see bottom ash under secondary waste streams beginning on page D-6). Flyash that requires stabilization (see flyash under secondary waste streams beginning on page D-6). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page D-6).

Mixed Waste Integrated Program Logic Diagram

Name: Cemented Sludge **MWIR#:** IN-W157 **Subelement:** Treatment

Matrix: Solidified Process Residues / 3150 **Site:** Idaho National Engineering Laboratory

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Rotary Kiln (continued)			Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page D-6). Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1).
ALTERNATIVE - Vitrification Joule Heated Melter Refractory-lined reactor in which a pool of glass is maintained molten by joule heating; size-reduced waste is introduced into the glass pool and absorbed into the glass matrix; metal container must be managed separately.	The DOE has demonstrated melters on specific wastes Subsystems required Waste shredder or grinder and system to separate waste and plastic from metal container Waste feed system Metal waste container treatment system Glass additive feed system Molten glass handling system Secondary combustion chamber Small offgas treatment system, including acid gas scrubber and particulate filter Projected performance The need to tightly control melt chemistry may complicate operation Addition of glass formers to maintain desired viscosity may limit the volume reduction Highly stable glass final waste form	Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems and the durability of the system's materials of construction. Demonstration should include: combined wastes.	High power requirements. This technology will be commercially available for waste applications within 2 years, and is currently in use for highly specialized applications in the DOE system. Unit operational costs and life cycle costs fall in the mid range of the group of thermal technologies. Large number of subsystems required and need to carefully control melt chemistry make this technology relatively complicated and labor-intensive. The mixed composition of this waste stream is not a good match for this technology. Medium development risk compared to the other thermal technologies. Input waste stream characterization information needed Chemical composition of sludge, specific sodium, calcium, chloride, sulfate, phosphate, and silica concentrations for glass development (see chemical composition in the characterization subelement beginning on page D-9). Waste streams produced Stabilized glass can be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see stabilized glass disposal beginning on page N-1). Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page D-6). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page D-6).
Plasma Arc Furnace Refractory-lined chamber into which unopened, containerized waste is introduced and melted in the high-temperature arc of a plasma torch. High-temperature volatilities of certain metals (such as arsenic, cadmium, lead, and selenium) may	A large scale proof-of-principle pilot batch unit has been demonstrated. A pilot system with a continuous feed system and melt removal system is currently being designed.	Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems.	Very high power requirements. This technology is far from commercial availability, but should be proven in 3-5 years. Unit operational costs are comparable to joule melter, but life cycle costs are low, due to volume reduction effects on disposal costs. Minimal subsystem requirements make this technology

Mixed Waste Integrated Program Logic Diagram

Name: Cemented Sludge **MWIR#:** IN-W157 **Subelement:** Treatment

Matrix: Solidified Process Residues / 3150 **Site:** Idaho National Engineering Laboratory

Alternative/Technology

require the subsequent capture of the metals in the offgas. The offgases would be subsequently cooled in order to allow any metals (or compounds) to condense out to low levels prior to being entrained via a particulate removal device. Since this material has already been incinerated it is unlikely that high levels of volatile metals are present. A secondary combustion chamber will be required for destruction of organics.

Status

Subsystems required
- Waste feed system
- Molten material handling system
- Offgas treatment system, including acid gas scrubber and particulate filters
- Glass former addition may be required, although testing on sludge has not shown a need for glass formers

Projected performance
- Highest temperature range, good organic destruction with no pretreatment
- Maximum volume reduction
- Highly stable slag and metal final waste forms
- Offgas system particulate filters and flyash can be processed through the furnace

Science and Technology Needs

Implementation Analysis

extremely simple and non-labor intensive. Ideally suited to process this waste stream with no pretreatment. Highest development risk of all of the thermal technologies.

Input waste stream characterization information needed

No specific characterization requirements for this waste stream.

Waste streams produced

Slag may be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see slag disposal beginning on page N-1).

Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page D-6).

Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page D-6).

Mixed Waste Integrated Program Logic Diagram

Name: Cemented Sludge **MWIR#:** IN-W157 **Subelement:** Treatment

Matrix: Solidified Process Residues / 3150 **Site:** Idaho National Engineering Laboratory

Secondary Waste Stream	Treatability Group
Bottom ash Flyash Offgas particulate filters Scrubber residue	**Radiological Constituents:** This waste may be classified as a waste containing 10-100 nCi/g of alpha-emitting radionuclides. However the waste may possibly be classified as TRU waste, if the radionuclides in the waste feed become concentrated within the products generated by the treatment process. **Contaminants:** Toxic heavy metals including chromium and lead. The following EPA regulated wastes are suspected to be contained within the waste stream: F001:Halogenated solvents used for degreasing F002:Halogenated solvents and mixtures F003:Non-halogenated solvents **Matrix:** This waste consists of ash, residues, and filters.

Mixed Waste Integrated Program Logic Diagram

Name: Cemented Sludge **MWIR#:** IN-W157 **Subelement:** Treatment

Matrix: Solidified Process Residues / 3150 **Site:** Idaho National Engineering Laboratory

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Alternative Solidification/Stabilization			
Polyethylene Polyethylene is an inert thermoplastic material that can be processed at low temperatures. Polyethylene binder and dry waste material are fed through separate calibrated volumetric or loss-in-weight feeders to an extruder. The materials are then thoroughly mixed, heated to a molten condition, and extruded into a suitable mold. On cooling, the mixture forms a solid monolithic waste form. No chemical reaction is required for solidification.	Polyethylene is being developed by DOE for use in these types of waste streams. Polyethylene has been demonstrated on scrubber residues. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual constituents contained within the waste stream. The technology needs development on the treatment of particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The percent of soluble salts contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see process residue salt content in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see solidified waste forms disposal beginning on page N-1).
Sulfur Polymer Cement (SPC) Sulfur Polymer Cement is composed of 95% sulfur. It melts at approximately 110 to 120°C and is particularly applicable to the immobilization of toxic metals and treatment of incinerator ash.	SPC is being developed by the DOE for usage within these types of waste streams. SPC has been demonstrated on waste ash. SPC is not compatible with waste streams that contain high nitrates. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual constituents contained within the waste stream. The technology needs development on the treatment of shredded particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The percent of soluble salts contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see process residue salt content in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: Cemented Sludge **MWIR#:** IN-W157 **Subelement:** Treatment

Matrix: Solidified Process Residues / 3150 **Site:** Idaho National Engineering Laboratory

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Chemically-bonded Ceramics (CbC) → Chemically-bonded ceramic waste forms are produced by mixing the wastes and inorganic oxide binders together. The mixture is then processed at ambient and near ambient temperatures, promoting chemical reactions that bond the waste and the inorganic oxides into a dense ceramic material.	CbC is in early stages for development by the DOE for use in these types of waste streams. → Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual constituents contained within the waste stream. The technology needs development on the treatment of particulate filters. →	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The percent of soluble salts contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see process residue salt content in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program

Logic Diagram

Idaho National Engineering Laboratory
Cemented Sludge
Characterization Technologies

Mixed Waste Integrated Program Logic Diagram

Name: Cemented Sludge **MWIR#:** IN-W157 **Subelement:** Characterization

Matrix: Solidified Process Residues / 3150 **Site:** Idaho National Engineering Laboratory

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Alkali metal (such as sodium and potassium) content.	Alternative/Technology Atomic Absorption, Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following methods for determining the concentration of potassium and sodium in wastes: EPA Method 258.1 - potassium (detection limit 0.01 mg/L) EPA Method 273.1 - sodium (detection limit 0.002 mg/L)	None, with proper sample preparation. This is a well-developed technology.	Method(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required.
	Alternative/Technology Ion Chromatography (IC)	Accepted by EPA and industry. Ion Chromatography (EPA Method 300.0) is able to quickly and accurately determine anions in solution to ppm or ppb concentrations. In order to use IC for solids, an extraction method outlined in EPA Method 300.0 must be performed. Additional separation techniques may be needed to further separate ionic species. EPA Method 300.0 - fluoride (detection limit 0.01 mg/L) EPA Method 300.0 - chloride (detection limit 0.02 mg/L) EPA Method 300.0 - nitrate (detection limit 0.002-0.004 mg/L) EPA Method 300.0 - sulfate (detection limit 0.02 mg/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available.
	Alternative/Technology Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES's primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is	None, with proper sample preparation. This is a well-developed technology.	Method(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).

Mixed Waste Integrated Program Logic Diagram

Name: Cemented Sludge **MWIR#:** IN-W157 **Subelement:** Characterization

Matrix: Solidified Process Residues / 3150 **Site:** Idaho National Engineering Laboratory

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (continued)	background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a consistent flow of sample to the instrument via the use of a peristolic pump, and/or by the use of the standard additions method. EPA Method 200.7 - potassium (detection limit 0.3 mg/L) EPA Method 200.7 - sodium (detection limit 0.03 mg/L)		
	Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8.	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s) available.
Chemical composition of sludge, specific sodium, calcium, chloride, sulfate, and silica concentrations for glass development.	Alternative/Technology Atomic Absorption, Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following methods for determining the concentration of potassium and sodium in wastes: EPA Method 215.1 - calcium (detection limit 0.01 mg/L) EPA Method 273.1 - sodium (detection limit 0.002 mg/L)	None, with proper sample preparation. This is a well-developed technology	Method(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required.

Mixed Waste Integrated Program Logic Diagram

Name: Cemented Sludge **MWIR#:** IN-W157 **Subelement:** Characterization

Matrix: Solidified Process Residues / 3150 **Site:** Idaho National Engineering Laboratory

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Alternative/Technology Ion Chromatography (IC)	Accepted by EPA and industry. Ion Chromatography (EPA Method 300.0) is able to quickly and accurately determine anions in solution to ppm or ppb concentrations. In order to use IC for solids, an extraction method outlined in EPA Method 300.0 must be performed. Additional separation techniques may be needed to further separate ionic species. EPA Method 300.0 - chloride (detection limit 0.02 mg/L) EPA Method 300.0 - sulfate (detection limit 0.02 mg/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available.
	Alternative/Technology Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES's primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a consistent flow of sample to the instrument via the use of a peristolic pump, and/or by the use of the standard additions method.	None, with proper sample preparation. This is a well-developed technology.	Method(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).

Mixed Waste Integrated Program Logic Diagram

Name: Cemented Sludge **MWIR#:** IN-W157 **Subelement:** Characterization

Matrix: Solidified Process Residues / 3150 **Site:** Idaho National Engineering Laboratory

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	(Continuation of Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry)	EPA Method 200.7 - calcium (detection limit 0.01 mg/L) EPA Method 200.7 - sodium (detection limit 0.03 mg/L) EPA Method 200.7 - silica (detection limit 0.02 mg/L)		
	Alternative/Technology Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8).	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s) available.
	Alternative/Technology Colorimetry for dissolved silica	Accepted by EPA. Colorimetry of silica (EPA Method 370.1)is applicable to aqueous samples in which the silica is dissolved. Thus solid samples of the waste must be digested prior to analysis. The estimated minimum detectable amount of silica via EPA Method 370.1 is 2mg/L.	None, with appropriate sample preparation.	Method(s) available. Excessive color and/or turbidity interfere. This may be corrected by running blanks prepared without addition of ammonium molybdate solution. Large amounts of iron and sulfide also interfere.

Mixed Waste Integrated Program

Logic Diagram

Idaho National Engineering Laboratory
Particulate Wastes (a-LLW)
Treatment Technologies

Mixed Waste Integrated Program Logic Diagram

Name: Particulate Wastes (a-LLW) **MWIR#:** IN-W264 **Subelement:** Treatment

Matrix: Predominantly Inorganic Non-Metal Debris / 5430 **Site:** Idaho National Engineering Laboratory

Waste Stream

Waste Stream Description

This waste stream consists of dirt, soil, etc. from floor sweepings; blacktop and concrete from clean-up efforts; grit from grit-blasting operations; and sludge from incineration activities.

The characterization information for this waste stream is limited, and some of the data presented are inconsistent. In the MWIR waste profile sheet, the waste is designated with the RCRA characteristic of corrosivity (EPA Code D002). However, the waste form evaluation for IDC 374 states that there are no toxic or corrosive materials present in the waste stream. Based on the description of the waste it has been assumed for selecting technology options that the waste is not corrosive because no liquids are present in the waste form.

The wastes are stored in carbon-steel 55-gallon drums and 4'x4'x7' wooden boxes.

Problems Presented by Waste Stream

Since the waste stream contains alpha emitters between 10 to 100 nCi/g, it is possible that it is also contaminated with TRU radionuclides that could present potential problems during handling, containment, and treatment.

The presence of spent solvents requires LDR treatment using an organic destruction technology followed by stabilization of the residues. However, the presence of lead (D008) and its high-temperature volatility may present problems in an offgas treatment system and will therefore require special treatment. The lead captured in the offgas will require that the offgas be subsequently cooled to condense the lead prior to the lead's removal in an offgas treatment device.

Treatability Group

Radiological Constituents:
This waste may be classified as a waste containing 10-100 nCi/g of alpha-emitting radionuclides. However the waste may be classified as TRU waste, if the radionuclides in the waste feed become concentrated within the products generated by the treatment process.

Low-level (10-100 nCi/g) alpha-emitting radionuclides (contact-handled)
Am-241
Pu-52
Beta-gamma emitter (<200 mR/hr at the surface)

Contaminants:
This waste stream is contaminated with spent solvents. The following EPA-regulated wastes are suspected to be contained within the waste stream.

D002: Unlisted hazardous waste characteristic of corrosivity
D008: Lead
D019: Carbon Tetrachloride
D040: Trichloroethylene
F001: Spent halogenated solvents used in degreasing
F002: Spent halogenated solvents and mixtures
F003: Spent nonhalogenated solvents
F004: Spent nonhalogenated solvents

Matrix:
This matrix consists of inorganic non-metal debris, particulate material, and sludges.

Mixed Waste Integrated Program Logic Diagram

Name: Particulate Wastes (a-LLW) **MWIR#:** IN-W264 **Subelement:** Treatment

Matrix: Predominantly Inorganic Non-Metal Debris / 5430 **Site:** Idaho National Engineering Laboratory

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
CHEMICAL TREATMENT There are no appropriate chemical treatment technologies applicable to this waste stream.			
THERMAL TREATMENT			
ALTERNATIVE – Thermal Desorption			
Retorting/roasting Low-temperature thermal unit in which volatile and semivolatile organics will be vaporized for subsequent capture in the offgas. Volatilization of constituents is less likely to occur than in an incinerator due to lower operating temperatures. At the lower operating temperatures, the lead present in the waste will not volatilize into the offgas, and therefore will stay with the residues. The lead will need to be subsequently stabilized. A secondary combustion chamber will be required for destruction of the organics captured in the offgas.	Accepted by industry. This technology is BDAT for high-mercury contaminated nonwastewaters. Subsystems required Feed pretreatment shredder for large items (may not be necessary for this waste stream based on the waste description) Feed system Moderate offgas treatment system, including acid gas scrubber, and particulate filters Secondary combustion system Ash handling system Projected performance Good organic destruction in secondary combustor Post-treatment stabilization of ash residues Long-term leaching performance is suspect especially because of the presence of lead in the residues Volume reduction is minimal	Better characterization data on extent of vaporization of waste constituents, determination of solidification requirements for roasted waste materials including the selection of an appropriate solidification agent, and determination of whether the waste will require mixing to expose all of the contaminants to the processing temperatures. Demonstration of the residuals passing TCLP tests will be required after stabilization.	Normal implementation needs. Treatment residue will require treatment/stabilization prior to disposal. This technology and its subsystems are commercially available and are currently in use in the commercial sector for this waste type. Few moving parts, but large number of subsystems required make this technology relatively complicated and labor intensive. <u>Input Waste Stream Characterization Information Needed</u> Better characterization of waste stream to determine nature and extent of alpha- contamination, especially the presence of TRU radionuclides, and also the presence or absence of corrosives needs to be verified (see TRU radionuclides in the characterization subelement beginning on page E-10). <u>Waste Streams Produced</u> Bottom ash, that requires stabilization (see bottom ash under secondary waste stream treatment beginning on page E-7). Flyash that requires stabilization (see flyash under secondary waste stream treatment beginning on page E-7). Scrubber residue that requires stabilization (see scrubber residue under secondary waste stream treatment beginning on page E-7). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste stream treatment beginning on page E-7).
ALTERNATIVE – Incineration			
Rotary Kiln Cylindrical refractory-lined shell mounted on a slight incline; rotation of the kiln moves the noncontainerized waste through while enhancing mixing. A high-temperature secondary-combustion chamber is required to complete organic destruc-	Accepted by industry. This technology is BDAT for organics and metal-contaminated nonwastewaters. The DOE is operating a rotary kiln in LLW service. Subsystems required Feed pretreatment shredder for large items as well	Better characterization of the waste stream to determine the extent of vaporization of other waste constituents. Demonstration of metal condensing process from the incineration offgas would be required.	Normal implementation needs. Captured metals and treatment residue will require treatment/stabilization prior to disposal. Rotary kiln incineration technology is commercially available and is currently in use and planned in the DOE system. The required subsystems, except for the metal condensation and collec-

Mixed Waste Integrated Program Logic Diagram

Name: Particulate Wastes (a-LLW) **MWIR#:** IN-W264 **Subelement:** Treatment

Matrix: Predominantly Inorganic Non-Metal Debris / 5430 **Site:** Idaho National Engineering Laboratory

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Rotary Kiln (continued) tion. The high-temperature volatility of lead requires its subsequent capture in the incinerator offgas. The incinerator offgases would be subsequently cooled to allow the lead in the offgas to condense out prior to the final offgas treatment device.	as concrete and blacktop Feed system Secondary-combustion chamber Large offgas treatment system, including acid gas scrubber, metal removal system, and particulate filters Ash handling system Projected performance Good organic destruction Rotating kiln seals questionable for contamination control		tion system, as described above are commercially available. The moving parts and large number of subsystems required make this technology relatively complicated and labor intensive. <u>Input Waste Stream Characterization Information Needed</u> Characterization requirements may include volatile metals for this waste stream in this technology (see TRU radionuclides in the characterization subelement beginning on page E-10) Better characterization of waste stream to determine nature and extent of alpha contamination especially the presence of TRU radionuclides (see volatile metals in the characterization subelement beginning on page E-10) The presence/absence of corrosive compounds needs to be verified (The acid and salt content will be used to correlate the corrosivity of the waste material) (see pH in the characterization subelement beginning on page M-12 and salt content in the characterization subelement beginning on page B-11). <u>Waste Streams Produced</u> Bottom ash, that requires stabilization (see bottom ash under secondary waste stream treatment beginning on page E-7). Flyash that requires stabilization (see flyash under secondary waste stream treatment beginning on page E-7). Scrubber residue that requires stabilization (see scrubber residues under secondary waste stream treatment beginning on page E-7). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste stream treatment beginning on page E-7).
ALTERNATIVE – Vitrification Joule Heated Melter Refractory-lined reactor in which a pool of glass is maintained molten by Joule heating; size-reduced waste is introduced into the glass pool and dissolved into the glass matrix. High temperature volatility of lead will require the subsequent capture in the offgas. The offgases would be subsequently cooled in order to allow it to condense out to low levels prior to the final removal device. If any salts are present, which seems unlikely from the waste description, the process may require	Ready for demonstration. Subsystems required Waste shredder or grinder and system to reduce waste size (may not be required based on waste description) Waste feed system Glass additive feed system Molten glass handling system Small offgas treatment system, including acid gas scrubber, metal removal system, and particulate	Technology must be demonstrated on this waste stream, including operation of required subsystems.	High-power requirements. This technology will be commercially available for waste applications within 2 years, and is currently in use for highly specialized applications in the DOE system. Unit operational costs and life cycle costs fall in the mid range of this group of technologies. Large number of subsystems required and need to carefully control melt chemistry make this technology relatively complicated and labor-intensive. The limited characterization data for this waste stream must be updated in order to determine applicability of this technology. Medium devel-

Mixed Waste Integrated Program Logic Diagram

Name: Particulate Wastes (a-LLW) **MWIR#:** IN-W264 **Subelement:** Treatment

Matrix: Predominantly Inorganic Non-Metal Debris / 5430 **Site:** Idaho National Engineering Laboratory

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Joule Heated Melter(continued) the addition of significant volumes of glassification agents.	filter Projected performance Good organic destruction requires reduction pretreatment or extended periods in the melt Need to tightly control melt chemistry complicates operation Offgas system flyash can be processed through the melter Addition of glass formers to maintain viscosity limits otherwise excellent volume reduction Highly stable glass final waste form		opment risk compared to the other thermal technologies. Input Waste Stream Characterization Information Needed Characterization requirements include better characterization of waste stream to determine nature and extent of alpha contamination especially the presence of TRU radionuclides (see volatile metals in the characterization subelement beginning on page E-10) The salt content of the waste stream needs to be verified (see salt content in the characterization subelement beginning on page E-10). Waste streams produced Stabilized glass can be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see stabilized glass disposal beginning on page N-1). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page E-7). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page E-7). Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1).
Plasma Arc Furnace Refractory-lined chamber into which unopened, containerized waste is introduced and melted in the high-temperature arc of a plasma torch. The high-temperature volatilization of lead in the waste would require its subsequent capture in the incinerator offgas. A secondary combustion chamber for treatment of organics will be required. The incinerator offgases would be subsequently cooled in order to allow condensation of metals prior to the final offgas treatment device.	Large-scale pilot demonstration complete. A radioactive-waste bench scale system is under construction. Subsystems required Waste feed system Molten material handling system Offgas treatment system, including acid gas scrubber and particulate filters Projected performance Highest temperature range, good organic destruction with no pretreatment Maximum volume reduction Highly stable slag and metal final waste forms Offgas system particulate filters and flyash can be processed through the furnace	Technology must be demonstrated on this waste stream, including operation of required subsystems.	Very high power requirements. This technology is farthest from commercial availability, but should be proven in 3–5 years. Unit operational costs are comparable to Joule melter. Minimal subsystem requirements make this technology operationally simple. Ideally suited to process this waste stream with little to no pretreatment. Highest development risk of the thermal technologies. Input waste stream characterization information needed Characterization requirements may include the identification of volatile metals within the waste stream (see volatile metals in the characterization subelement beginning on page E-10). Waste streams produced Slag may be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see slag disposal begin-

Mixed Waste Integrated Program Logic Diagram

Name: Particulate Wastes (a-LLW) **MWIR#:** IN-W264 **Subelement:** Treatment

Matrix: Predominantly Inorganic Non-Metal Debris / 5430 **Site:** Idaho National Engineering Laboratory

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Plasma Arc Furnace (continued)			ning on page N-1). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page E-7). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page E-7).

Mixed Waste Integrated Program Logic Diagram

Name: Particulate Wastes (a-LLW) **MWIR#:** IN-W264 **Subelement:** Treatment

Matrix: Predominantly Inorganic Non-Metal Debris / 5430 **Site:** Idaho National Engineering Laboratory

Secondary Waste Stream	Treatability Group
Bottom ash Flyash Offgas particulate filters Scrubber residue	Radiological Constituents: This waste may be classified as a waste containing 10-100 nCi/g of alpha-emitting radionuclides. However the waste may be classified as TRU waste, if the radionuclides in the waste feed become concentrated within the products generated by the treatment process. Low-level (10-100 nCi/g) alpha-emitting radionuclides (contact-handled) Am-241 Pu-52 Beta-gamma emitter Contaminants: This waste stream is contaminated with spent solvents. The following EPA-regulated wastes are suspected to be contained within the waste stream. F001: Spent halogenated solvents used in degreasing F002: Spent halogenated solvents and mixtures F003: Spent nonhalogenated solvents F004: Spent nonhalogenated solvents Matrix: This waste matrix consists of ash, residues, and filters.

Mixed Waste Integrated Program Logic Diagram

Name: Particulate Wastes (a-LLW) **MWIR#:** IN-W264 **Subelement:** Treatment

Matrix: Predominantly Inorganic Non-Metal Debris / 5430 **Site:** Idaho National Engineering Laboratory

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
ALTERNATIVE – Solidification/Stabilization			
Polyethylene Polyethylene is an inert thermoplastic material that can be processed at low temperatures. Polyethylene binder and dry waste material are fed through separate calibrated volumetric or loss-in-weight feeders to an extruder. The materials are then thoroughly mixed, heated to a molten condition, and extruded into a suitable mold. On cooling, the mixture forms a solid monolithic waste form. No chemical reaction is required for solidification.	Polyethylene is being developed by the DOE for usage on these types of waste streams. Polyethylene has been demonstrated on scrubber residues. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and the compatibility of the process with the actual waste streams. The technology needs development for the treatment of particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input Waste Stream Characterization Information Needed</u> The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salts in the characterization subelement starting on page E-10). <u>Waste Streams Produced</u> Solidified waste form that requires RCRA LLW disposal (but could also be classified as RCRA LLW alpha-contaminated waste) (see solidified waste forms disposal beginning on page N-1).
Sulfur Polymer Cement (SPC) Sulfur Polymer Cement is composed of 95% sulfur. It melts at approximately 110 to 120°C and is particularly valuable in the immobilization of toxic metals and treatment of incinerator ash.	SPC is being developed by the DOE and has been demonstrated on ash and many other substances. It is not compatible with waste streams containing high concentrations of nitrates. Subsystems required Waste feed system Ingredients feed system Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and the processes' compatibility with the actual waste stream constituents.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input Waste Stream Characterization Information Needed</u> The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salts in the characterization subelement starting on page E-10). <u>Waste Streams Produced</u> Solidified waste form that requires RCRA LLW disposal (but could also be classified as RCRA LLW alpha-contaminated waste) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: Particulate Wastes (a-LLW) **MWIR#:** IN-W264 **Subelement:** Treatment

Matrix: Predominantly Inorganic Non-Metal Debris / 5430 **Site:** Idaho National Engineering Laboratory

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Chemically-bonded Ceramics (CbC) Chemically-bonded ceramic waste forms are produced by mixing the wastes and inorganic oxide binders together. The mixture is then processed at ambient and near ambient temperatures, promoting chemical reactions that bond the waste and the inorganic oxides into a dense ceramic material.	CbC is in early stages for development by the DOE. Subsystems required Waste feed system Ingredients feed system Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and the processes' compatibility with the actual waste stream constituents. The technology needs development for the treatment of particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input Waste Stream Characterization Information Needed The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salts in the characterization subelement starting on page E-10). Waste Streams Produced Solidified waste form that requires RCRA LLW disposal (but could also be classified as RCRA LLW alpha-contaminated waste) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program

Logic Diagram

Idaho National Engineering Laboratory
Particulate Wastes (a-LLW)
Characterization Technologies

Mixed Waste Integrated Program Logic Diagram

Name: Particulate Wastes (a-LLW) **MWIR#:** IN-W264 **Subelement:** Characterization

Matrix: Predominantly Inorganic Non-Metal Debris / 5430 **Site:** Idaho National Engineering Laboratory

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
TRU radionuclides	Alpha Spectrometry	Accepted and proven technology. Approximate detection for ^{239}Pu and ^{234}U is 10^{-2} Bq/L.	None, with proper sample preparation. Samples must be plated out in thin layers during sample preparation to avoid self-absorption which leads to lower counting efficiencies.	Instrument(s) available.
Volatile metals (such as arsenic, mercury, cadmium, selenium, and lead).	Atomic Absorption (AA), Furnace Technique	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.0). EPA has approved the following methods for determining the concentration of volatile metals in wastes: EPA Method 239.2 - lead (detection limit 1 ug/L).	None, with proper sample preparation.	Method(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Arsenic and selenium analysis can suffer from severe nonspecific absorption and light scattering by matrix components during atomization due to their low analytical wavelengths. Simultaneous background corrections must be made for all metals to avoid erroneously high results.
	Atomic Absorption (AA), Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.0). EPA has approved the following methods for determining the concentration of volatile metals in wastes: EPA Method 239.1 - lead (detection limit 0.1 mg/L).	None, with proper sample preparation.	Method(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required. For concentrations of cadmium below 0.02 mg/L, the furnace procedure (EPA Method 213.2) is recommended. For concentrations of lead below 0.2 mg/L, the furnace procedure (EPA Method 239.2) is recommended.
	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).

Mixed Waste Integrated Program Logic Diagram

Name: Particulate Wastes (a-LLW) **MWIR#:** IN-W264 **Subelement:** Characterization

Matrix: Predominantly Inorganic Non-Metal Debris / 5430 **Site:** Idaho National Engineering Laboratory

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (continued)	excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a consistent flow of sample to the instrument via the use of a peristolic pump, and/or by the use of the standard additions method. EPA Method 200.7 - lead (detection limit 0.01 mg/L)		
	Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8). EPA Method 200.8 - lead (detection limit 0.08 ug/L)	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s) available.
Concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides).	Alternative/Technology Atomic Absorption (AA), Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.0). Estimated instrument detection limits for analytes of interest are as follows: EPA Method 258.1 - potassium (detection limit 0.01 mg/L). EPA Method 273.1 - sodium (detection limit 0.002 mg/L)	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required.
	Alternative/Technology Ion Chromatography (IC)	Accepted by EPA and Industry. Ion Chromatography (EPA Method 300.0) is able to quickly and accurately determine anions in solution to ppm or ppb concentrations. In order to use IC for solids, an extraction method outlined in EPA Method 300.0 must be performed. Additional separation techniques may be needed to further separate ionic species.	None, with proper sample preparation.	Method(s)/Instrument(s) available.

Mixed Waste Integrated Program Logic Diagram

Name: Particulate Wastes (a-LLW) **MWIR#:** IN-W264 **Subelement:** Characterization

Matrix: Predominantly Inorganic Non-Metal Debris / 5430 **Site:** Idaho National Engineering Laboratory

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Ion Chromatography (IC) (continued)	EPA Method 300.0 - chloride (detection limit 0.02 mg/L) EPA Method 300.0 - nitrate (detection limit 0.002-0.004 mg/L) EPA Method 300.0 - sulfate (detection limit 0.02 mg/L)		
	Alternative/Technology Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a consistent flow of sample to the instrument via the use of a peristolic pump, and/or by the use of the standard additions method. EPA Method 200.7 - potassium (detection limit 0.3 mg/L) EPA Method 200.7 - sodium (detection limit 0.03 mg/L)	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).
	Alternative/Technology Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8).	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s)/Instrument(s) available.

Mixed Waste Integrated Program

Logic Diagram

Los Alamos National Laboratory
Spent Solvents
Treatment Technologies

Mixed Waste Integrated Program Logic Diagram

Name: Spent Solvents **MWIR#:** LA-W024 **Subelement:** Treatment

Matrix: Aqueous - Halogenated Organic Liquid / 2110 **Site:** Los Alamos National Laboratory

Waste Stream

Waste Stream Description

This waste stream consists of spent halogenated solvents.

Problems Presented by Waste Stream

The LDR treatment for this waste stream is organic destruction followed by stabilization of residues. This waste stream is very small in volume (8.9 cubic meters) and therefore will not justify the construction of a new facility for organic destruction. Since the radiologic characteristics for this waste stream are not known, it is difficult to match this stream to an existing DOE incineration facility. If TRU radionuclides are present, the Controlled Air Incinerator at LANL is the only facility that may be able to treat this waste stream. If TRU nuclides are not present in the waste stream it may be treated at either the TSCA incinerator at Oak Ridge or at the SEG incinerator, which is a commercial facility. The extent of the effect of fluorides present in the waste stream must be determined to ensure that are no problems arising from reactions with the refractory lining of the incinerator. In general, additional characterization data on this waste stream will be required, especially with respect to its radiologic properties.

Treatability Group

Radiological Constituents:
This waste is classified as a Beta-Gamma emitter and as a contact-handled waste with < 10 nCi/g of alpha-emitting radionuclides.

MLLW-CH
Pu-239
U-238

Contaminants:
This waste stream is contaminated with spent solvents. The following EPA-regulated wastes are suspected to be contained within the waste stream.

F001: Spent halogenated solvents used in degreasing
1,1,1-trichloroethane
Trichloroethylene
Methylene chloride
Chlorinated fluorocarbons

Matrix:
This waste matrix consists of aqueous halogenated liquids.

Mixed Waste Integrated Program Logic Diagram

Name: Spent Solvents **MWIR#:** LA-W024 **Subelement:** Treatment

Matrix: Aqueous - Halogenated Organic Liquid / 2110 **Site:** Los Alamos National Laboratory

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
CHEMICAL TREATMENT			
ALTERNATIVE – Dehalogenation			
Chemical dehalogenation using alkaline polyethylene glycol (APEG) or potassium hydroxide with polyethylene glycol (KPEG). Chemical dehalogenation systems mix wastes with a dehalogenation reagent such as APEG or KPEG and heat them in a reactor vessel. The dehalogenation reaction replaces halogens with polyethylene glycol, rendering the compound nonhazardous and generating a chlorinated-liquid secondary waste stream. The technology is most effective for wastes contaminated with halogenated-semivolatile organic compounds and is best suited for small volume waste streams. The KPEG process involves the catalytic reaction of a phase transfer catalyst with the halogenated compound to promote the reaction. The reaction is effective with a temperature of 70°C and a duration of 15 minutes to 1 hour. If a large amount of water (>20% by volume) or other reactants are present, the reaction times can be as high as 12 hours.	Chemical dehalogenation technology has been used on many chlorinated organics but its effectiveness on other halogens, especially fluorine, needs to be evaluated. Subsystems required Centrifuge system to separate precipitated salts Filtration system Organic solidification Projected performance Good dechlorination Uncertainty about treatment of fluorocarbons Chlorinated waste stream contains RCRA-listed compounds that would continue to characterize the treated waste as RCRA-regulated Chloride salts produced from the treatment of the RCRA-listed wastes would also be RCRA-regulated	Technology integration must be demonstrated on this waste stream especially concerning treatment of fluorides. Characterization of both of the output streams would be required to determine if they are RCRA regulated.	Higher than normal implementation needs. Treatment residues consisting of filtered salts and dehalogenated organic liquids will require stabilization. The required subsystems are commercially available and the subsystems are not complicated or numerous. Input Waste Stream Characterization Information Needed Identification of any TRU levels in the waste because the radiation level is either unknown or uncompiled (see identification of TRU waste levels in the characterization subelement beginning on page F-6). Waste Streams Produced Chloride salts (see chloride salts under secondary waste streams beginning on page F-5). Organic liquids without chlorides (see thermal treatment alternatives in this section).
THERMAL TREATMENT			
ALTERNATIVE – Organic Destruction			
Liquid Injection Incinerator Liquid waste material is introduced into the combustion chamber by specially designed nozzles. Different nozzle designs result in various droplet sizes which mix with air and fuel as needed. Following combustion, the resulting gases are cooled and treated to remove particulates and to neutralize acid gases. Operating temperatures range from 2000°F. The stream could also be injected into the second combustion chamber of any of several varieties of incinerators.	Post-treatment stabilization of ash residuals using cement is accepted by industry and commercially available. Subsystems required Large offgas treatment system, including acid gas scrubber, particulate filters, and ash-handling system Stabilization system for treatment residuals such as flyash and spent scrubber solution Projected performance Good organic destruction Reaction of hydrogen fluoride (HF) with refractory materials may be a problem Post-treatment stabilization of ash residuals using	Technology must be demonstrated on this waste stream, but the technology is well established.	Normal implementation needs. The first implementation issue is determination of the TRU level in the waste. The result will impact the treatment alternative selection. The large number of subsystems required make this technology relatively complicated and labor intensive, however the modular design of the incinerator and use of a wide variety of secondary fuels lower operational costs. Input Waste Stream Characterization Information Needed Identification of any TRU waste because the radiation level is either unknown or uncompiled (see identification of TRU waste levels in the characterization subelement beginning on page F-6).

Mixed Waste Integrated Program Logic Diagram

Name: Spent Solvents **MWIR#:** LA-W024 **Subelement:** Treatment

Matrix: Aqueous - Halogenated Organic Liquid / 2110 **Site:** Los Alamos National Laboratory

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Liquid Injection Incinerator (continued)	cement is in use; long-term leaching performance is suspect; volume reduction is minimal; alternate stabilization techniques are possible for better long-term performance		Waste Streams Produced Flyash (see flyash under secondary waste streams beginning on page F-5). Scrubber residue (see scrubber residue under secondary waste streams beginning on page F-5). Offgas particulate filters (see offgas particulate filters under secondary waste streams beginning on page F-5).
Steam Reforming Hazardous organic chemicals are destroyed by reaction with super-heated steam resulting in volatilization of organics to the vapor phase with some thermal decomposition and fragmentation of organic molecules. In catalytic steam reforming, the volatilized organics are adsorbed on a rhodium catalyst and oxidized by high-temperature steam. A noncatalytic version of this technology is also available where the volatilized organics are first passed through a moving bed of ceramic spheres that have been coated with an alkali base in order to react any inorganic acids that may have been released during the volatilization step. The volatilized organics are subsequently reduced to CO and H2 in a high-temperature steam reformer that operates at 1200°C.	It is a common industrial process that is used to make hydrogen gas from methane. The technology is currently undergoing demonstration for destruction of hazardous organic contaminants commonly found in DOE mixed wastes. A demonstration of the use of a commercial one ton per day noncatalytic steam reforming system is being planned for destruction of organic materials and inorganic salts. Full-scale application of this process is likely to take 2 to 3 years. Subsystems required Liquid feed system Moving bed evaporator or alternative for vaporization of feed and halogen capture Steam reforming system (including a high-temperature steam generator) Oxidizer system for CO and H2 Projected performance Greater than 99.99% destruction efficiencies have been achieved for many organic solvents commonly found in mixed wastes by both catalytic (800°C) and noncatalytic (1200°C) methods	Technology must be demonstrated on wastes containing high concentrations of chlorides, including operation of the required subsystems. Also, based on the demonstration, additional data must be obtained about the secondary waste streams to determine if they will pass TCLP tests.	Potential high cost of utilities for generation of high temperature steam. However, since steam reforming is not a combustion process, it does not require supplemental fuel and products of incomplete combustion are not generated as offgas contaminants. Therefore, if the technology can be demonstrated on this waste stream, overall system costs should be comparable to other thermal treatment processes and may be cheaper than incineration. This technology is not yet commercially available for chlorinated waste applications and may take 2 to 3 years for commercial-scale applications within the DOE system. The liquid form of this waste stream is a good match for this technology. Low development risk compared to the other thermal technologies. Input Waste Stream Characterization Information Needed Apart from radiological characterization, data requirements will include details of the hazardous constituents in the waste stream to determine the effectiveness, applicability, and appropriate process conditions for this stream and this technology (see organic contaminants in characterization subelement beginning on page F-6). Waste Streams Produced A residual slurry/sludge (see slurry/sludge under secondary waste streams beginning on page F-5).

Mixed Waste Integrated Program Logic Diagram

Name: Spent Solvents **MWIR#:** LA-W024 **Subelement:** Treatment

Matrix: Aqueous - Halogenated Organic Liquid / 2110 **Site:** Los Alamos National Laboratory

Secondary Waste Stream	Treatability Group
Chloride salts Flyash Scrubber residue Offgas particulate filters Slurry/Sludge	Radiological Constituents: This waste is classified as a Beta-Gamma emitter and as a contact-handled waste with < 10 nCi/g of alpha-emitting radionuclides. MLLW-CH Pu-239 U-238 Contaminants: The following EPA regulated wastes are suspected to be contained within the waste stream: F001: Spent halogenated solvents used in degreasing Matrix: This waste matrix consists of salts, ash, residue, filters, and slurry/sludge.

Mixed Waste Integrated Program Logic Diagram

Name: Spent Solvents **MWIR#:** LA-W024 **Subelement:** Characterization

Matrix: Aqueous - Halogenated Organic Liquid / 2110 **Site:** Los Alamos National Laboratory

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Identification of TRU levels	Alpha Spectrometry	Accepted and proven technology. Approximate detection for ^{239}Pu and ^{238}U in urine per the ICRP Publication 54 is 10^{-2} Bq/L.	None, with proper sample preparation. Samples must be plated out in thin layers during sample preparation to avoid self-absorption which leads to lower counting efficiencies. Algorithms may be needed in the case of multi-radionuclide samples to deconvolute alpha spectra.	Method(s)/instrument(s) available. Estimated capital costs: $30K.
Organic contaminants.	Gas Chromatography/Mass Spectrometry (GC/MS)	Accepted by EPA. Gas chromatography-mass spectrometry (GC-MS) is a technique which provides separation of volatile and semi-volatile organic molecules by gas chromatography and detection by mass spectrometry. Utilizes the separation characteristics of various chromatographic columns, qualitative and quantitative data are obtained by correlating masses detected with the elution times.	Technology is applicable as is. Benefit would be derived from faster chromatography to shorten analysis time.	Method(s)/instrument(s) available. Mature technology.
Concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides).	Alternative/Technology Atomic Absorption (AA), Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.0). EPA has approved the following methods for determining the concentration of potassium and sodium in wastes: EPA Method 258.1 - potassium (detection limit 0.01 mg/L) EPA Method 273.1 - sodium (detection limit 0.002 mg/L)	None, with proper sample preparation. This is a well-developed technology.	Method(s)/instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required.
	Alternative/Technology Ion Chromatography (IC)	Accepted by EPA and industry. Ion Chromatography (EPA Method 300.0) is able to quickly and accurately determine anions in solution to ppm or ppb concentrations. In order to use IC for solids, an extraction method outlined in EPA Method 300.0 must be performed. Additional separation techniques may be needed to further separate ionic species. EPA Method 300.0 - chloride (detection limit 0.02 mg/L) EPA Method 300.0 - nitrate (detection limit 0.002-0.004 mg/L) EPA Method 300.0 - sulfate (detection limit 0.02 mg/L)	None, with proper sample preparation.	Instrument(s) available. Estimated capital costs: $30K. Estimated cost per analysis: $25-$50.

Mixed Waste Integrated Program Logic Diagram

Name: Spent Solvents **MWIR#:** LA-W024 **Subelement:** Characterization

Matrix: Aqueous - Halogenated Organic Liquid / 2110 **Site:** Los Alamos National Laboratory

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Alternative/Technology Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a consistent flow of sample to the instrument via the use of a peristolic pump, and/or by the use of the standard additions method. EPA Method 200.7 - potassium (detection limit 0.3 mg/L) EPA Method 200.7 - sodium (detection limit 0.03 mg/L)	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7). Estimated capital cost: $150K. Estimated cost per analysis: $50-$100.
	Alternative/Technology Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8).	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s)/Instrument(s) available. Estimated capital costs: $170K. Costs per multi-element analysis: $50-$100.

Mixed Waste Integrated Program

Logic Diagram

Oak Ridge
TSCA Incinerator Ash
Treatment Technologies

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Ash **MWIR#:** 2480 **Subelement:** Treatment

Matrix: Ash / 3111 **Site:** Oak Ridge

Waste Stream

Waste Stream Description

TSCA Incinerator Ash was generated from a waste feed that contained halogenated and non-halogenated solvents, toxic heavy metals including; arsenic, cadmium, chromium, lead, selenium, and silver and waste-water treatment sludges from electroplating operations.

Although the incinerator waste feed had contained EPA-listed volatile organic compounds, these compounds are assumed to have been destroyed while being subjected to the previously performed incineration treatment process. Even though this waste stream is not expected to be contaminated with the volatile organics, the respective codes continue to be attributed to the waste stream, because the VOC's have been treated/destroyed but have not been de-listed by the EPA.

Problems Presented by Waste Stream

Since the waste material has been incinerated, no further treatment is required to destroy the organic consituents. The concentration of sulfur and residual carbon that are present in the ash may a solidification problem. LDR treatment requirement for the listed waste codes is incineration followed by stabilization (understanding that incineration is already done). This treatment will also be sufficient for the toxic characteristic components. Volume reduction of waste materials (and thus the concentration of the radionuclides) could change this low-level mixed waste into a TRU-classified waste.

The LDR treatment standard for incinerator ash prior to land disposal is treatment via a stabilization technology, such as macro/micro-encapsulation.

The lack of TCLP characterization forces some assumptions in order to select technology options. The presence of metals may complicate the treatment strategy if the concentrations are very high, since stabilization may not be acceptable for greater than trace quantities of some metals. Currently identified EPA waste codes include: F001, F002, F003, and F006. However, based on analytical results for wastes generated from 3/27/91 to 6/11/92 the following additional waste codes are considered to also be applicable: D004, D006, D007, D008, D010, and D011. Characterization of wastes through process knowledge has been performed without actual verification via a TCLP analysis.

Treatability Group

Radiological Constituents:
This waste is classified as contact-handled with 10-100 nCi/g of alpha contamination.

Contaminants:
This waste is contaminated with toxic heavy metals and sludges. The following EPA-regulated wastes are suspected to be contained within the waste stream. It is assumed that the volatile organic compounds have previously been destroyed via the incineration treatment process.

F001: Halogenated solvents used for degreasing
F002: Halogenated solvents and mixtures
F003: Non-halogenated solvents
F006: Wastewater treatment sludges from electroplating
D004: Arsenic
D006: Cadmium
D007: Chromium
D008: Lead
D010: Selenium
D011: Silver

Matrix :
This waste stream consists of ash.

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Ash **MWIR#:** 2480 **Subelement:** Treatment

Matrix: Ash / 3111 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
CHEMICAL TREATMENT Not applicable to this waste stream, because nothing can be gained by performing chemical treatment upon this waste stream. The organic compounds have been previously destroyed by an incineration process and the residual ash/sludge containing metal and salt particulate is now prepared for treatment via a stabilization process.			
THERMAL TREATMENT ALTERNATIVE - Vitrification Joule Heated Melter Refractory-lined reactor in which a pool of glass is maintained molten by joule heating; size-reduced waste is introduced into the glass pool and dissolved within the glass matrix. High-temperature volatilities of certain metals (such as arsenic, cadmium, lead, and selenium) may require the subsequent capture of metals in the offgas. Since this material has already been incinerated it is unlikely that high levels of volatile metals are present. The vitrification of the ash may require the addition of significant volumes of glassification agents.	Ready for demonstration. The DOE has developed this technology for usage on HLW. Demonstration on LLW is proceeding. Subsystems required Waste feed system Glass additive feed system Molten glass handling system Secondary combustion chamber Small offgas treatment system, including offgas scrubber, and particulate filter Projected performance The need to tightly control the chemistry of the melt complicates the operation of the process Addition of glass formers to maintain desired viscosity limits volume reduction Highly stable glass final waste form is produced.	Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems.	High power requirements. This technology will be commercially available for waste applications within 2 years, and is currently in use for highly specialized applications within the DOE system. Unit operational costs and life cycle costs fall in the mid-range of this group of technologies. Large number of subsystems required and the need to carefully control the chemistry of the melt makes this technology relatively complicated and labor-intensive. The dry-homogeneous nature of this waste stream is a good match for this technology. Medium development risk compared to the other thermal technologies. <u>Input waste stream characterization information needed</u> Characterization requirements may include the identification of volatile metals and vitrification qualities due to the salt content in this waste stream. Salts are primarily aluminum, calcium, phosphorus and sodium salts (see volatile metals and salt content in the characterization subelement beginning on page G-10). <u>Waste streams produced</u> Stabilized glass can be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see stabilized glass disposal beginning on page N-1). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page G-7). Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page G-7).

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Ash **MWIR#:** 2480 **Subelement:** Treatment

Matrix: Ash / 3111 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Plasma Arc Furnace Refractory-lined chamber into which unopened, containerized waste is introduced and melted in the high-temperature arc of a plasma torch. High-temperature volatilities of certain metals (such as arsenic, cadmium, lead, and selenium) may require the subsequent capture of metals in the offgas. The offgases would be subsequently cooled in order to allow any metals (or compounds) to condense and be entrained via a particulate removal device. Since this material has already been incinerated it is unlikely that high levels of volatile metals are present. A secondary combustion chamber for treatment of organics should not be required due to previous incineration.	A large scale proof-of-principle pilot batch unit has been demonstrated. A pilot system with a continuous feed system and melt removal is currently in design. Subsystems required Waste feed system Molten material handling system Offgas treatment system, including acid gas scrubber and particulate filters Projected performance Highest temperature range, good organic destruction with no pretreatment Maximum volume reduction Highly stable slag and metal final waste forms Offgas system particulate filters and flyash can be processed through the furnace.	Demonstration of a continuous process is scheduled for late 1994. Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems. Treatability tests will be required to determine if glass formers are necessary.	Very high power requirements. This technology is furthest from commercial availability, but should be proven in 3-5 years. Unit operational costs are comparable to the operational costs of a joule melter. Minimal feed pretreatment simplifies operations. Suited to process this waste stream with no pretreatment of the waste stream. Highest development risk of the thermal technologies. Input waste stream characterization information needed Characterization requirements may include the identification of volatile metals within this waste stream (see volatile metals in the characterization subelement beginning on page G-10). Waste streams produced Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page G-7). Slag may be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see slag disposal beginning on page N-1). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page G-7).
Microwave Melter A process that uses microwave energy to melt wastes within a metal container, either via a batch or continuous feed mode. High-temperature melt occurs at 1800°-2600°F, resulting in a glassy-monolithic waste material. Due to the temperatures utilized in this process, certain metals (such as arsenic, mercury, selenium, cadmium, and lead) may volatilize. Typical waste volume reductions resulting from this process may be as high as 60 to 80%. Depending on ash composition, glass formers may have to be added to the melt to produce a vitrified product.	A full-scale non-radioactive waste pilot plant has been demonstrated. Small-scale radioactive systems have demonstrated performance on the DOE wastes. Subsystems required Waste feed system Glass former addition system (probable addition) Projected performance Good organic destruction High volume reduction Stable glass waste form Reduced handling requirements and generation of secondary wastes through in-drum processing	Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems. Preliminary testing at PNL indicates a need for glass formers.	Very high power requirements. This technology is not yet commercially available, but should be proven in 2-4 years. Unit operational costs are high due to low throughput when compared to a joule melter or plasma arc furnace, but life cycle costs on the microwave melter are low, due to volume reduction effects on disposal costs. Minimal subsystem requirements make this technology extremely simple and non-labor intensive. Suited to process this waste stream with no pretreatment of the waste stream. Medium development risk of the thermal technologies. Input waste stream characterization information needed Characterization requirements may include the identification of volatile metals within this waste stream (see volatile metals in the characterization

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Ash **MWIR#:** 2480 **Subelement:** Treatment

Matrix: Ash / 3111 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Microwave Melter (continued)			subelement beginning on page G-10). Waste streams produced Scrubber residue that require stabilization (see scrubber residue under secondary waste streams beginning on page G-7). Slag may be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see slag disposal beginning on page N-1). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page G-7).
PHYSICAL TREATMENT ALTERNATIVE - Solidification/Stabilization			
Polyethylene Polyethylene is an inert thermoplastic material that can be processed at low temperatures. Polyethylene binder and dry waste material are fed through separate calibrated volumetric or loss-in-weight feeders to an extruder. The materials are then thoroughly mixed, heated to a molten condition, and extruded into a suitable mold. On cooling, the mixture forms a solid monolithic waste form. No chemical reaction is required for solidification.	Polyethylene is being developed by the DOE for usage within these types of waste streams. Polyethylene has been demonstrated on scrubber residues. Subsystems required Waste feed system Ingredients feed system Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal.	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual constituents contained in the waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input waste stream characterization information needed The percent soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). Waste streams produced A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).
Sulfur Polymer Cement (SPC) Sulfur Polymer Cement is composed of 95% sulfur. It melts at approximately 110 - 120°C, and is particularly applicable to the immobilization of toxic metals and treatment of incinerator ash.	SPC is being developed by the DOE for usage within these types of waste streams. SPC has been demonstrated on ash. SPC is not compatible with high nitrates. Subsystems required Waste feed system Ingredients feed system Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal.	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual constituents contained in the waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input waste stream characterization information needed The percent soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). Waste streams produced A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Ash **MWIR#:** 2480 **Subelement:** Treatment

Matrix: Ash / 3111 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Chemically-bonded Ceramics (CbC) - Chemically-bonded ceramic waste forms are produced by mixing the wastes and inorganic oxide binders together. The mixture is then processed at ambient and near-ambient temperatures, promoting chemical reactions that bond the waste and the inorganic oxides into a dense ceramic material.	CbC is in early stages for development by the DOE for usage within these types of waste streams. Subsystems required Waste feed system Ingredients feed system Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal.	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual constituents contained in the waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The percent soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Ash **MWIR#:** 2480 **Subelement:** Treatment

Matrix: Ash / 3111 **Site:** Oak Ridge

Secondary Waste Stream	Treatability Group
Offgas particulate filters Scrubber residue	Radiological Constituents: This waste may be classified as a waste containing 10-100 nCi/g of alpha-emitting radionuclides. However the waste may be classified as TRU waste, if the radionuclides in the waste feed become concentrated within the products generated by the treatment process. Contaminants: This waste is contaminated with toxic heavy metals including arsenic, cadmium, chromium, lead, selenium, and silver. F001: Halogenated solvents used for degreasing F002: Halogenated solvents and mixtures F003: Non-halogenated solvents F006: Wastewater treatment sludges from electroplating Matrix : This waste consists of filters and scrubber residue.

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Ash **MWIR#:** 2480 **Subelement:** Treatment

Matrix: Ash / 3111 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
PHYSICAL TREATMENT ALTERNATIVE - Solidification/Stabilization			
Polyethylene Polyethylene is an inert thermoplastic material that can be processed at low temperatures. Polyethylene binder and dry waste material are fed through separate calibrated volumetric or loss-in-weight feeders to an extruder. The materials are then thoroughly mixed, heated to a molten condition, and extruded into a suitable mold. On cooling, the mixture forms a solid monolithic waste form. No chemical reaction is required for solidification.	Polyethylene is being developed by the DOE for usage within these types of waste streams. Polyethylene has been demonstrated on scrubber residues. Subsystems required Waste feed system Ingredients feed system Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal.	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual constituents contained in the waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input waste stream characterization information needed The percent soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). Waste streams produced A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).
Sulfur Polymer Cement (SPC) Sulfur Polymer Cement is composed of 95% sulfur. It melts at approximately 110 - 120°C, and is particularly applicable to the immobilization of toxic metals and treatment of incinerator ash.	SPC is being developed by the DOE for usage within these types of waste streams. SPC has been demonstrated on ash. SPC is not compatible with high nitrates. Subsystems required Waste feed system Ingredients feed system Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal.	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual constituents contained in the waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input waste stream characterization information needed The percent soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). Waste streams produced A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).
Chemically-bonded Ceramics (CbC) Chemically-bonded ceramic waste forms are produced by mixing the wastes and inorganic oxide binders together. The mixture is then processed at ambient and near ambient temperatures, promoting chemical reactions that bond the waste and the inorganic oxides into a dense ceramic	CbC is in early stages for development by the DOE for usage within these types of waste streams. Subsystems required Waste feed system Ingredients feed system	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual constituents contained in the waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input waste stream characterization information needed The percent soluble salt contained in the scrubber

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Ash **MWIR#:** 2480 **Subelement:** Treatment

Matrix: Ash / 3111 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Chemically-bonded Ceramics (CbC) (continued) material.	Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal.		residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). Waste streams produced A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program

Logic Diagram

Oak Ridge
TSCA Incinerator Ash
Characterization Technologies

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Ash **MWIR#:** 2480 **Subelement:** Characterization

Matrix: Ash / 3111 **Site:** Oak Ridge

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Volatile metals (such as arsenic, cadmium, selenium, and lead).	Alternative/Technology Atomic Absorption, Furnace Technique	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.0). EPA has approved the following methods for determining the concentration of volatile metals in wastes: EPA Method 206.2 - arsenic (detection limit 1 ug/L) EPA Method 213.2 - cadmium (detection limit 0.1 ug/L) EPA Method 270.2 - selenium (detection limit 2 ug/L) EPA Method 239.2 - lead (detection limit 1 ug/L)	None, with proper sample preparation.	Method(s)/Instrument(s)available. Care must be taken to minimize the loss of volatile metals during sample preparation. Arsenic and selenium analysis can suffer from severe nonspecific absorption and light scattering by matrix components during atomization due to their low analytical wavelengths. Simultaneous background corrections must be made for all metals to avoid erroneously high results.
	Alternative/Technology Atomic Absorption, Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.0). EPA has approved the following methods for determining the concentration of volatile metals in wastes: EPA Method 213.1 - cadmium (detection limit 0.005 mg/L) EPA Method 239.1 - lead (detection limit 0.1 mg/L)	None, with proper sample preparation.	Method(s)/Instrument(s)available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required. For concentrations of cadmium below 0.02 mg/L, the furnace procedure (EPA Method 213.2) is recommended. For concentrations of lead below 0.2 mg/L, the furnace procedure (EPA Method 239.2) is recommended.
	Alternative/Technology Inductively-Coupled Plasma Spectroscopy (ICP)	Accepted. ICP's primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP is background radiation from other elements and the plasma gases. Although all ICP instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s)available. Use of ICP (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Ash **MWIR#:** 2480 **Subelement:** Characterization

Matrix: Ash / 3111 **Site:** Oak Ridge

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Inductively-Coupled Plasma Spectroscopy (ICP) (continued)	interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a consistent flow of sample to the instrument via the use of a peristolic pump, and/or by the use of the standard additions method. EPA Method 200.7 - arsenic (detection limit 0.008 mg/L) EPA Method 200.7 - cadmium (detection limit 0.001 mg/L) EPA Method 200.7 - selenium (detection limit 0.02 mg/L) EPA Method 200.7 - lead (detection limit 0.01 mg/L)		
	Alternative/Technology Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8). EPA Method 200.8 - arsenic (detection limit 0.9 ug/L) EPA Method 200.8 - cadmium (detection limit 0.1 ug/L) EPA Method 200.8 - selenium (detection limit 5 ug/L) EPA Method 200.8 - lead (detection limit 0.08 ug/L)	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s)/Instrument(s) available.
Salt content (salts are primarily aluminum, calcium, phosphorus, and sodium salts).	Alternative/Technology Atomic Absorption, Direct Aspiration.	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.0). EPA has approved the following methods for determining the concentration of potassium and sodium in wastes: EPA Method 202.1 - aluminum (detection limit 0.1 mg/L) EPA Method 215.1 - calcium (detection	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required.

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Ash **MWIR#:** 2480 **Subelement:** Characterization
Matrix: Ash / 3111 **Site:** Oak Ridge

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Atomic Absorption, Direct Aspiration (continued)	limit 0.01 mg/L) EPA Method 273.1 - sodium (detection limit 0.002 mg/L)		
	Alternative/Technology Ion Chromatography (IC)	Accepted by EPA and industry. Ion Chromatography (EPA Method 300.0) is able to quickly and accurately determine anions in solution to ppm or ppb concentrations. In order to use IC for solids, an extraction method outlined in EPA Method 300.0 must be performed. Additional separation techniques may be needed to further separate ionic species. EPA Method 300.0 - chloride (detection limit 0.02 mg/L) EPA Method 300.0 - nitrate (detection limit 0.002-0.004 mg/L) EPA Method 300.0 - sulfate (detection limit 0.02 mg/L)	None, with proper sample preparation.	Instrument(s) available.
	Alternative/Technology Inductively-Coupled Plasma Spectroscopy (ICP)	Accepted. ICP's primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP is background radiation from other elements and the plasma gases. Although all ICP instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccura-	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s)available. Use of ICP (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Ash **MWIR#:** 2480 **Subelement:** Characterization

Matrix: Ash / 3111 **Site:** Oak Ridge

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Inductively-Coupled Plasma Spectroscopy (ICP) (continued)	cies. EPA Method 200.7 - aluminum (detection limit 0.02 mg/L) EPA Method 200.7 - calcium (detection limit 0.01 mg/L) EPA Method 200.7 - sodium (detection limit 0.03 mg/L)		
→	Alternative/Technology Inductively-Coupled Plasma Mass Spectrometry (ICP-MS) →	Accepted by EPA. Provides multi-element analysis that is more selective than ICP. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8). →	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation. →	Method(s)/Instrument(s) available.

Mixed Waste Integrated Program

Logic Diagram

Oak Ridge
TSCA Incinerator Sludge
Treatment Technologies

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Sludge **MWIR#:** 2508 **Subelement:** Treatment

Matrix: Offgas Treatment Sludges / 3123 **Site:** Oak Ridge

Waste Stream

Waste Stream Description

TSCA Incinerator sludge waste feed stream consisted of halogenated and non-halogenated solvents, toxic heavy metals including; arsenic, cadmium, chromium, lead, selenium, and silver and wastewater treatment sludges from electroplating operations.

Although the incinerator waste feed had contained EPA-listed volatile organic compounds, these compounds are assumed to have been destroyed while being subjected to the previously performed incineration treatment process. Even though this waste stream is not expected to be contaminated with volatile organics, the respective codes continue to be attributed to the waste stream, because the VOC's have been treated/destroyed but have not be de-listed by the EPA.

Problems Presented by Waste Stream

LDR treatment requirement for the listed waste codes is incineration followed by stabilization. This treatment will also be sufficient for the toxic characteristic components. The LDR treatment standard for incinerator ash after treatment but prior to land disposal is stabilization via a treatment technology such as macro/micro-encapsulation.

The lack of TCLP characterization forces some assumptions in order to select technology options. The presence of metals may complicate the treatment strategy if the concentrations are very high, since stabilization may not be acceptable for greater than trace quantities of some metals. Currently identified EPA waste codes include: F001, F002, F003, and F006. However based on analytical results for wastes generated from 3/27/91 to 6/11/92 for the TSCA ash, the following additional waste codes are also considered to be applicable: D004, D006, D007, D008, D010, and D011. Characterization of wastes through process knowledge has been done without actual verification via TCLP analysis. It is assumed that PBCs thought to have been previously contained in the waste stream have been destroyed by the TSCA incinerator.

Treatability Group

Radiological Constituents:
This waste is classified as contact-handled with 10 -100 nCi/g of alpha contamination.

Contaminants:
This waste stream is contaminated with solvent, heavy metals, and sludges. It is assumed that the volatile organic compounds have previously been destroyed via the incineration treatment process:

F001: Halogenated solvents used for degreasing
F002: Halogenated solvents and mixtures
F003: Non-halogenated solvents
F006: Wastewater treatment sludges from electroplating
D004: Arsenic
D006: Cadmium
D007: Chromium
D008: Lead
D010: Selenium
D011: Silver

Matrix:
This waste consists of offgas treatment sludges.

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Sludge **MWIR#:** 2508 **Subelement:** Treatment

Matrix: Offgas Treatment Sludges / 3123 **Site:** Oak Ridge

Alternative/Technology

CHEMICAL TREATMENT

Not applicable to this waste form, because nothing can be gained by performing chemical treatment upon this waste stream. The organic compounds have been previously destroyed by an incineration process and the residual ash/sludge containing metal and salt particulate is now prepared for treatment via a stabilization process.

THERMAL TREATMENT

ALTERNATIVE - Vitrification

Joule Heated Melter

Refractory-lined reactor in which a pool of glass is maintained molten by joule heating; waste is introduced within the glass pool and dissolved into the glass matrix. High-temperatures can volatilize certain metals (such as arsenic, mercury, selenium, cadmium, and lead) and may require the subsequent capture of the metals in the offgas. Sludge may require the addition of significant volumes of glassification agents to ensure the vitrification of the waste.

Status

The DOE has demonstrated vitrification systems using HLW. Vitrification on several LLW matrices is under way. Pacific National Laboratory (PNL) has conducted bench scale testing of TSCA sludge vitrification.

Subsystems required
- Waste feed system
- Glass additive feed system
- Molten glass handling system
- Secondary combustion chamber
- Small offgas treatment system, including acid-gas scrubber, metal-recovery system, and particulate filter
- Scrub solution treatment system

Projected performance
- The need to tightly control the chemistry of the melt complicates operation of the process
- Addition of glass formers to maintain desired viscosity limits volume reduction
- Highly stable glass final waste form is produced.

Science and Technology Needs

Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems.

Implementation Analysis

High power requirements. This technology will be commercially available for waste applications within 2 years, and is currently in use for highly specialized applications within the DOE system. Unit operational costs and life cycle costs fall in the mid-range of this group of technologies. Large number of subsystems required and the need to carefully control the chemistry of the melt, make this technology relatively complicated and labor-intensive. The homogeneous nature of this waste stream is a good match for this technology. Medium development risk compared to the other thermal technologies.

Input waste stream characterization information needed

Characterization requirements may include the identification of volatile metals and vitrification qualities due to potential salt content in this waste stream (see volatile metals in the characterization subelement beginning on page H-10).

Waste streams produced

Stabilized glass can be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see stabilized glass disposal beginning on page N-1).

Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page H-7).

Empty containers can be disposed of as LLW (see empty container disposal beginning on page N-1).

Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page H-7).

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Sludge **MWIR#:** 2508 **Subelement:** Treatment

Matrix: Offgas Treatment Sludges / 3123 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Plasma Arc Furnace Refractory-lined chamber into which unopened, containerized waste is introduced and melted in the high-temperature arc of a plasma torch. High-temperatures can volatilize certain metals (such as arsenic, mercury, selenium, cadmium, and lead) requiring the subsequent capture of the metals in the offgas. The offgases would be subsequently cooled in order to allow any metals (or compounds) to condense and be entrained in a particulate removal device. A secondary combustion chamber for treatment of organics is commonly included (in this case should not be required).	A large scale proof-of-principle pilot batch unit has been demonstrated. An upgraded pilot plant with a continuous feed system and melt removal is currently in design Subsystems required Waste feed system Molten material handling system for slag and metal phases. Offgas treatment system, including acid gas scrubber and particulate filters. Projected performance Highest temperature range, good organic destruction with no pretreatment. Maximum volume reduction. Highly stable slag and metal final waste forms.	Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems. Analytical information is required. Glass formers may be necessary, although they have not been needed in any testing performed thus far.	Very high power requirements. This technology is furthest from commercial availability, but should be proven in 3-5 years. Unit operational costs are comparable to the operational costs of a joule melter. Minimized feed preparation requirements make this the simplest of the thermal technology options. Highest development risk of the thermal technologies. Input waste stream characterization information needed Characterization requirements may include the identification of volatile metals within this waste stream (see volatile metals in the characterization subelement beginning on page H-10). Waste streams produced Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page H-7). Slag may be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see slag disposal beginning on page N-1). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page H-7).
Microwave Melter A process that uses microwave energy to solidify wastes within the metal container, either via a batch or continuous feed mode. High-temperature melt occurs at between 1800°-2600°F resulting in a glassy-monolithic waste material. Due to the temperatures utilized in this process, certain metals (such as arsenic, mercury, selenium, cadmium, and lead) may volatilize. Glass formers are commonly added to produce a stable waste form.	A large scale non radioactive pilot plant has been operated. Subsystems required Waste feed system Offgas system Glass former addition system Projected performance Highly stable glass waste form Reduced handling requirements and generation of secondary wastes through in-drum processing.	Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems. Treatability tests would identify any stabilization additives that may be needed.	Very high power requirements. This technology is not yet commercial availability, but should be proven in 2-4 years. Unit operational costs are high due to low throughput comparable to joule melter or plasma arc furnace. Minimal subsystem requirements make this technology extremely simple and non-labor intensive. Suited to process this waste stream with no pretreatment. The corrosive nature of the sludge during microwaving may be a problem. Medium development risk of the thermal technologies. Input waste stream characterization information needed Characterization requirements may include the identification of volatile metals within this waste stream (see volatile metals in the characterization

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Sludge **MWIR#:** 2508 **Subelement:** Treatment
Matrix: Offgas Treatment Sludges / 3123 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Microwave Melter (continued)			subelement beginning on page H-10). Waste streams produced Slag may be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see slag disposal beginning on page N-1). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page H-7). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page H-7).
PHYSICAL TREATMENT Solidification/Stabilization			
Polyethylene Polyethylene is an inert thermoplastic material that can be processed at low temperatures. Polyethylene binders and dry waste materials are fed through separate calibrated volumetric or loss-in-weight feeders to an extruder. The materials are then thoroughly mixed, heated to a molten condition, and extruded into a suitable mold. On cooling, the mixture forms a solid monolithic waste form. No chemical reaction is required for solidification.	Polyethylene is being developed by the DOE for usage on these types of waste streams. Polyethylene has been demonstrated on scrubber residues. Subsystems required Waste feed system Ingredients feed system Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal.	Technology must be demonstrated on this waste stream to ensure the stabilization of the toxic constituents and the compatibility of the process with actual constituents contained in the waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input waste stream characterization information needed The percent soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). Waste streams produced A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).
Sulfur Polymer Cement (SPC) Sulfur Polymer Cement is composed of 95% sulfur. It melts at approximately 110 to 120°C and is particularly applicable to the immobilization of toxic metals and treatment of incinerator ash.	SPC is being developed by the DOE for usage within these types of waste streams. SPC has been demonstrated on waste ash. SPC is not compatible with waste streams that contain high nitrates. Subsystems required Waste feed system Ingredients feed system Projected performance	Technology must be demonstrated on this waste stream to ensure the stabilization of toxic constituents and compatibility with the actual constituents contained in the waste stream. The technology needs development on the treatment of shredded particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input waste stream characterization information needed The percent soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Sludge **MWIR#:** 2508 **Subelement:** Treatment

Matrix: Offgas Treatment Sludges / 3123 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Sulfur Polymer Cement (SPC) (continued)	Expected to pass TCLP Expected to produce a suitable final waste form for disposal		12). Waste streams produced A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).
Chemically-bonded Ceramics (CbC) Chemically bonded ceramic waste forms are produced by mixing the wastes and inorganic oxide binders together. The mixture is then processed at ambient and near-ambient temperatures, promoting chemical reactions that bond the wastes and the inorganic oxides into a dense ceramic material.	CbC is in early stages for development by the DOE for usage within these types of waste streams. Subsystems required Waste feed system Ingredients feed system Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure the stabilization of toxic constituents and compatibility with the actual constituents contained in the waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input waste stream characterization information needed The percent soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). Waste streams produced A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Sludge **MWIR#:** 2508 **Subelement:** Treatment

Matrix: Offgas Treatment Sludges / 3123 **Site:** Oak Ridge

Secondary Waste Stream	Treatability Group
Offgas particulate filters Scrubber residues	Radiological Constituents: This waste may be classified as waste containing 10-100 nCi/g of alpha-emitting radionuclides. However the waste may possibly be classified as TRU waste, if the radionuclides in the waste feed become concentrated within the products generated by the treatment process. Contaminants: This waste stream is contaminated with toxic heavy metals including; arsenic, cadmium, chromium, lead, selenium, and silver. The following EPA-regulated wastes are suspected to be contained within the waste stream. It is assumed that the volatile organic compounds have previously been destroyed via the incineration treatment process: F001: Halogenated solvents used for degreasing F002: Halogenated solvents and mixtures F003: Non-halogenated solvents F006: Wastewater treatment sludges from electroplating Matrix: This waste consists of scrubber residues and offgas particulate filters.

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Sludge **MWIR#:** 2508 **Subelement:** Treatment

Matrix: Offgas Treatment Sludges / 3123 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
ALTERNATIVE: Solidification/Stabilization			
Polyethylene Polyethylene is an inert thermoplastic material that can be processed at low temperatures. Polyethylene binders and dry waste materials are fed through separate calibrated volumetric or loss-in-weight feeders to an extruder. The materials are then thoroughly mixed, heated to a molten condition, and extruded into a suitable mold. On cooling, the mixture forms a solid monolithic waste form. No chemical reaction is required for solidification.	Polyethylene is being developed by the DOE for usage on these types of waste streams. Polyethylene has been demonstrated on scrubber residues. Subsystems required Waste feed system Ingredients feed system Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal.	Technology must be demonstrated on this waste stream to ensure the stabilization of the toxic constituents and the compatibility of the process with actual constituents contained in the waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The percent soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).
Sulfur Polymer Cement (SPC) Sulfur Polymer Cement is composed of 95% sulfur. It melts at approximately 110 to 120°C and is particularly applicable to the immobilization of toxic metals and treatment of incinerator ash.	SPC is being developed by the DOE for usage within these types of waste streams. SPC has been demonstrated on waste ash. SPC is not compatible with waste streams that contain high nitrates. Subsystems required Waste feed system Ingredients feed system Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure the stabilization of toxic constituents and compatibility with the actual constituents contained in the waste stream. The technology needs development on the treatment of shredded particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The percent soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).
Chemically-bonded Ceramics (CbC) Chemically-bonded ceramic waste forms are produced by mixing the wastes and inorganic oxide binders together. The mixture is then processed at ambient and near ambient temperatures, promoting chemical reactions that bond the wastes and the inorganic oxides into a dense ceramic material.	CbC is in early stages for development by the DOE for usage within these types of waste streams. Subsystems required Waste feed system Ingredients feed system Projected performance Expected to pass TCLP	Technology must be demonstrated on this waste stream to ensure the stabilization of toxic constituents and compatibility with the actual constituents contained in the waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The percent soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Sludge **MWIR#:** 2508 **Subelement:** Treatment

Matrix: Offgas Treatment Sludges / 3123 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Chemically-bonded Ceramics (CbC) (continued)	Expected to produce a suitable final waste form for disposal		characterization subelement beginning on page M-12). Waste streams produced A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA-alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program

Logic Diagram

Oak Ridge
TSCA Incinerator Sludge
Characterization Technologies

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Sludge **MWIR#:** 2508 **Subelement:** Characterization

Matrix: Offgas Treatment Sludges / 3123 **Site:** Oak Ridge

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Volatile metals (such as arsenic, mercury, cadmium, selenium, and lead).	Alternative/Technology Atomic Absorption (AA), Furnace Technique	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following methods for determining the concentration of volatile metals in wastes: EPA Method 206.2 - arsenic (detection limit 1 ug/L) EPA Method 213.2 - cadmium (detection limit 0.1 ug/L) EPA Method 270.2 - selenium (detection limit 2 ug/L) EPA Method 239.2 - lead (detection limit 1 ug/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Arsenic and selenium analysis can suffer from severe nonspecific absorption and light scattering by matrix components during atomization due to their low analytical wavelengths. Simultaneous background corrections must be made for all metals to avoid erroneously high results.
	Alternative/Technology Atomic Absorption (AA), Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following methods for determining the concentration of volatile metals in wastes: EPA Method 213.1 - cadmium (detection limit 0.005 mg/L) EPA Method 239.1 - lead (detection limit 0.1 mg/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required. For concentrations of cadmium below 0.02 mg/L, the furnace procedure (EPA Method 213.2) is recommended. For concentrations of lead below 0.2 mg/L, the furnace procedure (EPA Method 239.2) is recommended.
	Alternative/Technology Atomic Absorption, Cold-Vapor	Accepted. Samples must be converted to suitable solutions for analysis. EPA has approved the following methods for determining the total mercury (inorganic and organic) in solid wastes: EPA Method 245.5 - mercury (detection limit .0002 mg/L)	None. All samples must be subject to an appropriate dissolution step prior to analysis.	Method(s)/Instrument(s) available. Potassium permanganate is added to eliminate possible interference from sulfide. Wastes high in chloride require additional permanganate. Certain volatile organic absorb at the wavelength of mercury vapor (253.7-nm). A preliminary run without reagents should determine if this type of interference is present.
	Alternative/Technology Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES's primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Sludge **MWIR#:** 2508 **Subelement:** Characterization

Matrix: Offgas Treatment Sludges / 3123 **Site:** Oak Ridge

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (continued)	acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a constant flow to the instrument via the use of a peristolic pump, and/or by the use of the standard additions method. EPA Method 200.7 - arsenic (detection limit 0.008 mg/L) EPA Method 200.7 - mercury (detection limit 0.02 mg/L) EPA Method 200.7 - cadmium (detection limit 0.001 mg/L) EPA Method 200.7 - selenium (detection limit 0.02 mg/L) EPA Method 200.7 - lead (detection limit 0.01 mg/L)		analyte concentrations may arise - see Table 2, EPA Method 200.7).
	→ Alternative/Technology Inductively-Coupled Plasma Mass Spectrometry (ICP-MS) →	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8). EPA Method 200.8 - arsenic (detection limit 0.9 ug/L) EPA Method 200.8 - cadmium (detection limit 0.1 ug/L) EPA Method 200.8 - selenium (detection limit 5 ug/L) EPA Method 200.8 - lead (detection limit 0.08 ug/L) →	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation. →	Method(s)/Instrument(s) available.

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Sludge **MWIR#:** 2508 **Subelement:** Characterization

Matrix: Offgas Treatment Sludges / 3123 **Site:** Oak Ridge

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Salt content	Alternative/Technology Atomic Absorption, Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following methods for determining the concentration of potassium and sodium in wastes: EPA Method 258.1 - potassium (detection limit 0.01 mg/L) EPA Method 273.1 - sodium (detection limit 0.002 mg/L)	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required.
	Alternative/Technology Ion Chromatography (IC)	Accepted by EPA and industry. Ion Chromatography (EPA Method 300.0) is able to quickly and accurately determine anions in solution to ppm or ppb concentrations. In order to use IC for solids, an extraction method outlined in EPA Method 300.0 must be performed. Additional separation techniques may be needed to further separate ionic species. EPA Method 300.0 - fluoride (detection limit 0.01 mg/L) EPA Method 300.0 - chloride (detection limit 0.02 mg/L) EPA Method 300.0 - nitrate (detection limit 0.002-0.004 mg/L) EPA Method 300.0 - sulfate (detection limit 0.02 mg/L)	None, with proper sample preparation.	Instrument(s) available.
	Alternative/Technology Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES's primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).

Mixed Waste Integrated Program Logic Diagram

Name: TSCA Incinerator Sludge **MWIR#:** 2508 **Subelement:** Characterization
Matrix: Offgas Treatment Sludges / 3123 **Site:** Oak Ridge

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Alternative/Technology Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (continued)	and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a constant flow to the instrument via the use of a peristolic pump, and/or by the use of the standard additions method. EPA Method 200.7 - potassium (detection limit 0.3 mg/L) EPA Method 200.7 - sodium (detection limit 0.03 mg/L)		
	Alternative/Technology Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8).	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s)/Instrument(s) available.

Mixed Waste Integrated Program

Logic Diagram

Oak Ridge
Y-12 Hazardous Solid Waste
Treatment Technologies

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Waste Stream

Waste Stream Description:

Hazardous waste solid generated during plant operations at ORNL Y-12 facility.

Y-12 solid waste contains hazardous chlorinated solvents, inorganic debris, toxic organics and metals. The Resource Conservation and Recovery Act (RCRA) Best Demonstrated Available Technology (BDAT) for treatment of the hazardous solvents in this waste is incineration. Thermal treatment is the preferred treatment for the organic components. Stabilization at the Mixed Waste Treatment Facility is the preferred treatment for process residuals and inorganic solids remaining after incineration/thermal treatment is complete. Stabilized wastes requiring disposal will include aqueous salts from off-gas treatment systems, dry solid residuals to which stabilizers may be added, discarded metal drums and other waste containers.
The alternate LDR treatment standard for debris (it is not obvious that this stream meets the debris rule criteria) is treatment prior to land disposal using any of the following technologies: extraction (physical, chemical or thermal), destruction (biological, chemical, or thermal), macro/microencapsulation or sealing. The debris rules are not applied in this analysis.

Problems Presented by Waste Stream:

The characterization data concerning the physical and chemical form is not available for the waste. The F006 waste code is listed, however, the volume and physical state of the electroplating sludge is not stated.

If the electroplating sludge is separate or well defined and not mixed in with the other general debris, it may be able to be solidified for disposal. It is assumed that the waste form is predominantly solid debris contaminated with metal residues and organics.

LDR treatments required for the listed waste codes are incineration, recovery, chemical reduction, acid leaching, or high-temperature metal recovery; all followed by stabilization.

The alternate LDR treatment standard for debris is treatment prior to land disposal using any of the following technologies: extraction (physical, chemical, thermal), destruction (biological, chemical, or thermal), macro/microencapsulation or sealing.

Treatability Group

Radiological Constituents:
This waste is classified as contact-handled with 10 -100 nCi/g of alpha contamination.

Contaminants:
This waste is contaminated with toxic organics and mercury. The following EPA regulated wastes are suspected to be contained within the waste stream:

D001:Unlisted hazardous waste characteristic of ignitability
D006:Cadmium
D007:Chromium
D008:Lead
D009:Mercury
F001:Halogenated solvents used in degreasing
F002:Halogenated solvents and mixtures
F006:Wastewater treatment sludges from electroplating
PCBs

Matrix:
The waste matrix consists of inorganic debris including the following:

Carbon filter used for crushing
Crushed fluorescent bulbs
Crushed fluorescent light tubes
Crushed fluorescent lamps
Filter
Filter cartridges
Fluorescent lamps
HCL & Soda Ash concrete and gravel
Lab instruments
Lab trash
Manometers and sweepings
Mercury contaminated asbestos
Mercury contaminated filter
Mercury contaminated hose
Mercury contaminated lead
Mercury contaminated paper
Mercury contaminated piping
Mercury contaminated polystyrene
Mercury contaminate pump parts
Mercury contaminated rags
Mercury contaminated solids
Mercury contaminated trash
Mercury contaminated tiles
Mercury contaminated waste
Mercury fluorescent lamps
Mercury vapor lamps from hot cell
Mersorb filter
PCB plastic drum 7

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Treatment
Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Waste Stream	Treatability Group
Waste Stream Description (continued)	PCB solids (diapers) PCB solids paper, plastic Rad filter Respirator cartridges Rubber lining (PCB HO) Sorball clean up material Trash T.S wipes Tube machine Stokes gauge U-contaminated trash Waste paper and plastic Wipes

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Alternative/Technology

CHEMICAL TREATMENT

Decontamination via an Acidic Rinse; Chemical Oxidation; Chemical Reduction
(Note: Although only a few chemical oxidation reagents have been identified here, various reagents that could be utilized to perform chemical oxidation include ozone, permanganate, hydrogen peroxide, hypochlorite, and sulfur dioxide. Various oxidation techniques utilized could include wet air oxidation, electrolytic oxidation, or ozonation via an ultraviolet light.)
Wastes will be sorted into categories of combustibles, liquid mercury, mercury-contaminated asbestos, and metals.

Chemical treatment technologies are only applicable to the liquid mercury and large portions of this stream.

Combustibles (including combustibles contaminated with PCBs) and small metal pieces will be treated via incineration or stabilization(see thermal treatment or physical treatment).

Mercury-contaminated asbestos will be treated as debris via stabilization (see physical treatment).

Liquid mercury that has been drained from waste instrumentation and plumbing will be treated via amalgamation. Zinc metal powder (or copper) will be mixed with the liquid mercury and allowed to react, forming a zinc-mercury alloy (see secondary waste stream treatment).

Large Metal objects will be treated via decontamination, chemical oxidation, chemical reduction, and dehydration/evaporation. Chemical immobilization of contaminants adhering to the surfaces of waste metals can be accomplished via an acidic spray or dip system. Acids utilized could include EDTA or citric acid combined with surfactants. If rigorous treatment was required, nitric acid could be utilized. Organics contained in the acidic rinse can be destroyed via chemical oxidation (utilizing hydrogen peroxide or permanganate as the oxidizer under conditions in the pH range of 1-4). If PCBs are contained within the waste

Status

Amalgamation; decontamination via an acidic rinse; chemical oxidation; chemical reduction; and dehydration/evaporation technologies have been previously used in industry on similar waste types.

Subsystems required
- Manual sorting system
- Amalgamation system
- Acidic rinse system
- Chemical oxidation system
- Caustic addition system
- Chemical reduction system
- Dehydration/evaporation system

Projected performance
- Expected to pass TCLP
- Expected to produce a suitable final waste form for disposal

Science and Technology Needs

Demonstration of this technology with respect to the treatment of these specific contaminants within this specific waste matrix is needed.

Implementation Analysis

Many subsystems make the treatment of this waste stream labor intensive. Acid utilization within the presence of alpha contamination may cause safety concerns.

<u>Input waste stream characterization information needed</u>
<u>Waste stream</u>:
Concentration and form of mercury contaminants. (see concentration and chemical form of mercury in the characterization subelement beginning on page I-19).

<u>Liquid Mercury</u>:
Chemical form and concentration of the mercury (see concentration and chemical form of mercury in the characterization subelement beginning on page I-19).
Solution pH (see pH in the characterization subelement beginning on page I-19).
Presence of interfering materials, such as oils and greases (see presence and concentration of oil and grease in the characterization subelement beginning on page M-12).
Presence of suspended particles (see presence and concentration of suspended solids in the characterization subelement beginning on page M-12).
Presence of dissolved salts (see presence of dissolved salts in the characterization subelement beginning on page I-19).

<u>Acidic rinsate</u>:
An accurate COD analysis of the waste is required to determine the reagents necessary to promote oxidation of the organics within the waste (see Chemical-Oxygen Demand analysis in the characterization subelement beginning on page I-19).
Concentration of metal salts. Metal salts, especially silver salts, will react with the oxidizing agents to form metal oxides which can interfere with the effectiveness of the treatment process (see metal salts in the characterization subelement beginning on page I-19).
pH of the waste (see pH in the characterization subelement beginning on page I-19).
The presence and concentration of cyanide and

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
solution, an oxidation technique utilizing hydrogen peroxide in combination with an ultraviolet light will destroy them. After the destruction of the organics, the acidic rinse can be raised to a pH of 4-5, and ferrous sulfate added to precipitate the metal contaminants. The slurry is then dehydrated/evaporated down to a sludge (~ 60-80 wt. %) to enable the physical treatment of the heavy metal contaminants via stabilization (see physical treatment - stabilization). The required concentrations of the reagents will be based on the Chemical-Oxygen Demand(COD) analysis of the solution. Temperature control and Oxidation-Reduction Potential (ORP) monitoring are standard control technologies utilized for COD analysis. The process can be monitored via the COD analysis to determine when the organics are completely destroyed. For accurate COD analysis, the hydrogen peroxide (if utilized as the oxidizer) must be neutralized prior to the performance of the analysis.			PCBs within the waste rinsate will be necessary to select the appropriate oxidation treatment method (see cyanide and PCBs in the characterization subelement beginning on page I-19). <u>Waste streams produced</u> Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1), Sludge that requires stabilization (see sludge under secondary waste streams beginning on page I-14). Decontaminated metal debris can be disposed of as a LLW (see metal debris disposal beginning on page N-1). Mercury zinc alloy can be disposed of as LLW (but could be classified as alpha-contaminated or TRU waste) (see solidified waste forms disposal beginning on page N-1).
→ Decontamination via CO2 Blasting; Chemical Oxidation; Chemical Reduction (Note: Although only a few chemical oxidation reagents have been identified here, various reagents that could be utilized to perform chemical oxidation include ozone, permanganate, hydrogen peroxide, hypochlorite, and sulfur dioxide. Various oxidation techniques utilized could include wet air oxidation, electrolytic oxidation, or ozonation via an ultraviolet light.) Wastes will be sorted into categories of combustibles, liquid mercury, mercury-contaminated asbestos, and metals. Chemical treatment technologies are only applicable to the liquid mercury and large metals portions of this waste stream. Combustibles (including combustibles contaminated with PCBs) and small metal pieces will be treated via incineration (see thermal treatment or physical treatment).	→ Decontamination via CO2 Blasting; Chemical Oxidation; Chemical Reduction; and Dehydration/Evaporation technologies have been previously used in industry on similar waste types. Subsystems required Manual sorting system Amalgamation system CO2 blasting system Chemical oxidation system Acid addition system Chemical reduction system Dehydration/evaporation system Projected performance Expected to produce a suitable product that can be stabilized into a final waste form for disposal	→ Demonstration of this technology with respect to the treatment of these specific contaminants within this specific waste matrix is needed.	→ Many subsystems make the treatment of this waste stream labor intensive. A pressurized spray within the presence of alpha contamination may cause safety concerns. <u>Input waste stream characterization information needed</u> <u>Waste stream:</u> Concentration and form of mercury contaminants (see concentration and chemical form of mercury in the characterization subelement beginning on page I-19). <u>Liquid Mercury:</u> Chemical form and concentration of the mercury (see concentration and chemical form of mercury in the characterization subelement beginning on page I-19). Solution pH (see pH in the characterization subelement beginning on page I-19). Presence of interfering materials, such as oils and greases (see presence and concentration of oil and

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Decontamination via CO2 Blasting (continued) Mercury-contaminated asbestos will be treated as debris via stabilization (see physical treatment). Liquid mercury that has been drained from waste instrumentation and plumbing will be treated via amalgamation. Zinc metal powder (or copper) will be mixed with the liquid mercury at ambient - 60°C temperatures, and allowed to react, forming a zinc-mercury alloy (see secondary waste stream treatment). Large metal objects will be treated via decontamination, chemical oxidation, chemical reduction, and dehydration/evaporation. Chemical immobilization of contaminants adhering to the surfaces of waste metals can be accomplished via CO2 Blasting (CO2 Blasting is the removal of contamination via a pressurized spray of frozen carbon dioxide pellets). The frozen CO2 evaporates and the contaminants will be swept up off of the floor and treated via a caustic (hydrogen peroxide or permanganate) chemical oxidation process. If PCBs are contained within the waste solution, an oxidation technique utilizing hydrogen peroxide in combination with an ultraviolet light will destroy them. After the destruction of the organics, the solution can be lowered to a pH of 4-5, and ferrous sulfate added to precipitate the metal contaminants. The slurry is then dehydrated/evaporated down to a sludge (~ 60-80 wt. %) to enable the physical treatment of the heavy metal contaminants via stabilization (see physical treatment - stabilization). The required concentrations of the reagents will be based on the Chemical-Oxygen Demand (COD) analysis of the solution. Temperature control and Oxidation-Reduction Potential (ORP) monitoring are standard control technologies utilized for COD analysis. The process can be monitored via the COD analysis to determine when the organics are completely destroyed. For accurate COD analysis, the hydrogen peroxide (if utilized as the oxidizer) must be neutralized prior to the performance of the analysis.			grease in the characterization subelement beginning on page M-12). Presence of suspended particles (see presence and concentration of suspended solids in the characterization subelement beginning on page M-12). Presence of dissolved salts. Copper salts can react with zinc prior to the mercury-zinc reaction (see dissolved salts in the characterization subelement beginning on page I-19). <u>Oxidation process solution:</u> An accurate COD analysis of the waste is required to determine the reagents necessary to promote oxidation of the organics within the waste (see Chemical-Oxygen Demand analysis in the characterization subelement beginning on page I-19). Concentration of metal salts. Metal salts, especially silver salts, will react with the oxidizing agents to form metal oxides which can interfere with the effectiveness of the treatment process (see metal salts in the characterization subelement beginning on page I-19). pH of the waste (see pH in the characterization subelement beginning on page I-19). The presence and concentration of cyanide and PCBs within the waste process solution will be necessary to select the appropriate oxidation treatment method (see cyanide and PCBs in the characterization subelement beginning on page I-19). <u>Waste streams produced</u> Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1). Sludge that requires stabilization (see sludge under secondary waste streams beginning on page I-14). Decontaminated metal debris can be disposed of as a LLW (see metal debris disposal beginning on page N-1). Mercury zinc alloy can be disposed of as LLW (but could be classified as alpha-contaminated or TRU waste) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Alternative/Technology

Decontamination via Polyethylene-Bead Blasting; Chemical Oxidation; Chemical Reduction (Note: Although only a few chemical oxidation reagents have been identified here, various reagents that could be utilized to perform chemical oxidation include ozone, permanganate, hydrogen peroxide, hypochlorite, and sulfur dioxide. Various oxidation techniques utilized could include wet air oxidation, electrolytic oxidation, or ozonation via an ultraviolet light)

Wastes will be sorted into categories of combustibles, liquid mercury, mercury-contaminated asbestos, and metals.

Chemical treatment technologies are only applicable to the liquid mercury and large metals portions of this waste stream.

Combustibles (including combustibles contaminated with PCBs) and small metal pieces will be treated via incineration (see thermal treatment or physical treatment).

Mercury-contaminated asbestos will be treated as debris via stabilization (see physical treatment).

Liquid mercury that has been drained from waste instrumentation and plumbing will be treated via amalgamation. Zinc metal powder (or copper) will be mixed with the liquid mercury at ambient - 60°C temperatures, and allowed to react, forming a zinc-mercury alloy (see secondary waste stream treatment).

Large metal objects will be treated via decontamination, chemical oxidation, chemical reduction, and dehydration/evaporation. Chemical immobilization of contaminants adhering to the surfaces of waste metals can be accomplished via Polyethylene-Bead Blasting (Polyethylene-Bead Blasting is the removal of contamination via a pressurized spray of polyethylene beads). The contaminants adhere to the beads or will drop onto the floor. The contaminants and beads will be swept up off of the floor and treated via a caustic (hydrogen peroxide or permanganate)

Status

Decontamination via polyethylene-bead blasting; chemical oxidation; chemical reduction; and dehydration/evaporation technologies have been previously used in industry on similar waste types.

Subsystems required
- Manual sorting system
- Amalgamation system
- Polyethylene-Bead blasting system
- Chemical oxidation system
- Acid addition system
- Chemical reduction system
- Dehydration/evaporation system

Projected performance
- Expected to produce a suitable product that can be stabilized as a final waste form for disposal

Science and Technology Needs

Demonstration of this technology with respect to the treatment of these specific contaminants within this specific waste matrix is needed.

Implementation Analysis

Many subsystems make the treatment of this waste stream labor intensive. A pressurized spray within the presence of alpha contamination may cause safety concerns.

<u>Input waste stream characterization information needed</u>

<u>Waste stream:</u>

Concentration and form of mercury contaminants (see concentration and chemical form of mercury in the characterization subelement beginning on page I-19).

<u>Liquid Mercury</u>:

Chemical form and concentration of the mercury (see concentration and chemical form of mercury in the characterization subelement beginning on page I-19).

Solution pH (see pH in the characterization subelement beginning on page I-19).

Presence of interfering materials, such as oils and greases (see presence and concentration of oil and grease in the characterization subelement beginning on page M-12).

Presence of suspended particles (see presence and concentration of suspended solids in the characterization subelement beginning on page M-12).

Presence of dissolved salts, copper salts can react with zinc prior to the mercury-zinc reaction (see dissolved salts in the characterization subelement beginning on page I-19).

<u>Oxidation process solution</u>:

An accurate COD analysis of the waste is required to determine the reagents necessary to promote oxidation of the organics within the waste (Chemical-Oxygen Demand analysis in the characterization subelement beginning on page I-19).

Concentration of metal salts; metal salts, especially silver salts, will react with the oxidizing agents to form metal oxides which can interfere with the effectiveness of the treatment process (see metal salts in the characterization subelement beginning on page I-19).

The presence and concentration of cyanide and PCBs within the waste process solution will be necessary to select the appropriate oxidation treatment

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Decontamination via Polyethylene-Bead Blasting; Chemical Oxidation; Chemical Reduction (continued) chemical oxidation process. If PCBs are contained within the waste solution,an oxidation technique utilizing hydrogen peroxide in combination with an ultraviolet light will destroy them. After the destruction of the organics, the solution can be lowered to a pH of 4-5, and ferrous sulfate added to precipitate the metal contaminants. The slurry is then dehydrated/evaporated down to a sludge (~60-80 wt. %) to enable the physical treatment of the heavy metal contaminants via stabilization. The required concentrations of the reagents will be based on the Chemical-Oxygen Demand(COD) analysis of the solution. Temperature control and Oxidation-Reduction Potential (ORP) monitoring are standard control technologies utilized for COD analysis. The process can be monitored via the COD analysis to determine when the organics are completely destroyed. For accurate COD analysis, the hydrogen peroxide (if utilized as the oxidizer) must be neutralized prior to the performance of the analysis.			method (see cyanide and PCBs in the characterization subelement beginning on page I-19). <u>Waste streams produced</u> Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1). Sludge that requires stabilization (see sludge under secondary waste streams beginning on page I-14). Decontaminated metal debris can be disposed of as a LLW (see metal debris disposal beginning on page N-1). Mercury zinc alloy can be disposed of as LLW (but could be classified as alpha-contaminated or TRU waste) (see solidified waste forms disposal beginning on page N-1).
→ THERMAL TREATMENT → ALTERNATIVE - Incineration → Controlled Air Incineration (CAI) A stationary hearth incinerator usually designed with a two or three stage combustion process. Solid wastes are fed into a primary chamber to be burned using sub-stoichiometric air, thus destroying the volatile constituents. A high-temperature secondary combustion chamber is operated with excess air to ensure the complete destruction of volatile organic materials. Liquid waste materials are burned either in the primary or secondary chambers dependent upon their characteristics. High-temperature volatilities of certain metals (such as arsenic, mercury, selenium, cadmium, and lead) require the subsequent capture in the incinerator offgas. The incinerator offgases would be subsequently cooled in order to allow these metals (or compounds) to condense and be	Accepted by industry, commercially available. The DOE has operated controlled air incinerators in LLW service. Subsystem required Feed sorting for separation of non-combustibles Feed shredder for large solids (if applicable) Offgas treatment system, including offgas scrubber, particulate filters, and mercury sorbents Secondary combustion chamber Ash handling system Stabilization system for treatment residuals Projected performance Good organic destruction Post-treatment stabilization of ash residuals using cement is currently in widely used	Better characterization of the waste stream to determine the extent of volatilization of metallic waste constituents. Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems. Demonstration of ash immobilization meeting TCLP requirements is needed.	Normal implementation needs. Captured metals and treatment residue will require treatment/stabilization prior to disposal. Controlled air incineration technology is commercially available and is currently planned for usage within the DOE system for this waste type. The required subsystems, except for the mercury collection system, are commercially available. The large number of subsystems required make this technology relatively complicated and labor intensive. However, the modular design of the incinerator and usage of a wide variety of secondary fuels lower operational costs. Separation of noncombustibles and glass can be labor intensive. <u>Input waste stream characterization information needed</u> Characterization requirements may include the

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Thermal Treatment (continued) entrained via a particulate removal device. CAI's operate best on combustible waste, with small amounts of non-combustibles. Separation of easily vitrified materials, such as glass, prior to waste treatment will be required in order for this waste stream to be compatible with this technology.	Volume reduction is high for combustibles Alternate stabilization techniques possible for better long-term performance		identification of volatile metals in the waste stream. (see volatile metals in the characterization subelement of this waste stream). Waste streams produced Bottom ash that requires stabilization (see bottom ash under secondary waste streams beginning on page I-14). Flyash that requires stabilization (see flyash under secondary waste streams beginning on page I-14). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page I-14). Offgas particulate filters that requires stabilization (see offgas particulate filters under secondary waste streams beginning on page I-14). Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1). Mercury offgas (see mercury offgas under secondary waste streams beginning on page I-17).
Rotary Kiln Cylindrical refractory-lined shell mounted on a slight incline; rotation of the kiln moves the noncontainerized waste through while enhancing mixing. High-temperature volatilities of certain metals (such as arsenic, mercury, selenium, cadmium, and lead) require the subsequent capture of the metals in the incinerator offgas. The incinerator offgases would be subsequently cooled in order to allow these metals (or compounds) to condense and be entrained via a particulatel removal device. A high-temperature secondary combustion chamber is also required to complete organic destruction. Rotary kilns cannot be used in a service involving routine thermal cycling.	Accepted by industry. The EPA has approved this technology as the BDAT for organics and metal-contaminated nonwastewaters. The DOE is operating a rotary kiln in LLW service, and Post-treatment stabilization of ash residuals using cement is currently in use. Subsystems required Feed pretreatment shredder for large items (as applicable) Feed system Secondary combustion chamber Large offgas treatment system, including offgas scrubber, particulate filters, and mercury sorbents Ash handling system Stabilization system for treatment residuals Projected performance Good organic destruction Rotating kiln seals are questionable regarding con-	Better characterization of the waste stream is necessary to determine the extent of volatilization of other waste constituents. Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems. Demonstration of residuals immobilization meeting TCLP requirements is needed.	Normal implementation needs. Captured metals and treatment residue will require treatment/stabilization prior to disposal. The rotary kiln incineration technology is commercially available and currently used within the commercial sector. The technology is currently in use within the DOE sector for non-cemented sludge wastes. The required subsystems, except for the mercury capture and collection system, are commercially available. The moving parts and large number of subsystems required make this technology relatively complicated and labor intensive. Rotary kilns cannot tolerate frequent startup/shutdown cycles, so a substantial waste feed backlog is necessary to justify implementation. Input waste stream characterization information needed Characterization requirements may include the identification of volatile metals within this waste stream (see volatile metals in the characterization subelement beginning on page I-19).

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis

Alternative/Technology

Rotary Kiln (continued)

Status

tamination control

Continuous operation at elevated temperatures is required

Implementation Analysis

Waste streams produced

Bottom ash that requires stabilization (see bottom ash under secondary waste streams beginning on page I-14).

Flyash that requires stabilization (see flyash under secondary waste streams beginning on page I-14).

Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page I-14).

Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page I-14).

Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1).

Mercury offgas (see mercury offgas under secondary waste streams beginning on page I-17).

Alternative/Technology

ALTERNATIVE - Vitrification

Joule Heated Melter

Refractory-lined reactor in which a pool of glass is maintained molten by joule heating; size-reduced waste is introduced into the glass pool and dissolved into the glass matrix. High-temperature volatilities of certain metals (such as arsenic, mercury, selenium, cadmium, and lead) require the subsequent capture of the metals in the offgas. The offgases would be subsequently cooled in order to allow these metals (or compounds) to condense and be entrained via a particulate removal device. Salt content may require the addition of significant volumes of glassification agents.

Status

The DOE has developed the technology for application to HLW. Demonstration on some LLW is in progress.

Subsystems required

- Sorting system to remove metals
- Waste shredder or grinder and system to reduce waste size (as applicable)
- Waste feed system
- Glass additive feed system
- Molten glass handling system
- Secondary combustion chamber
- Offgas treatment system, including acid gas scrubber, metal removal system, and particulate filter

Projected performance

- Good organic destruction requires reduction pretreatment or extended periods in the melt
- Need to tightly control melt chemistry complicates operation
- Offgas system flyash can be processed through the melter
- Addition of glass formers to maintain desired viscosity limits volume reduction
- Highly stable glass final waste form

Science and Technology Needs

Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems. Most DOE demonstrations for vitrification have been performed using homogeneous solids or sludges.

Implementation Analysis

High power requirements. This technology will be commercially available for waste applications within 2 years, and is currently in use for highly specialized applications within the DOE system. Unit operational costs and life cycle costs fall in the mid-range of this group of technologies. Large number of subsystems are required and need carefully controlled melt chemistry to make this technology relatively complicated. The variable characteristics of this waste stream may not be a good match for this technology. Medium development risk compared to the other thermal technologies.

Input waste stream characterization information needed

Characterization requirements may include the identification of volatile metals and vitrification qualities due to glass content of this waste stream (see volatile metals in the characterization subelement beginning on page I-19).

Waste streams produced

Stabilized glass can be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see stabilized glass disposal beginning on page N-1).

Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Joule Heated Melter (continued)			streams beginning on page I-14). Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1). Mercury offgas (see mercury offgas under secondary waste streams beginning on page I-17).
Plasma Arc Furnace Refractory-lined chamber into which unopened, containerized waste is introduced and melted in the high-temperature arc of a plasma torch. High-temperature volatilities of certain metals (such as arsenic, mercury, selenium, cadmium, and lead) require the subsequent capture of the metals in the offgas. The offgases would be subsequently cooled in order to allow these metals (or compounds) to condense and be entrained via a particulate removal device. A secondary combustion chamber for treatment of organics is commonly included. Offgas system particulate filters and fly-ash can be processed through the furnace.	A large-scale proof-of-principle pilot batch unit has been demonstrated. Upgrades at the pilot plant to a continuous feed system and melt removal are currently in design. Subsystems required Waste feed system (with size reduction as applicable to oversize containers) Molten material handling system for slag and metal Secondary combustion chamber Offgas treatment system, including offgas scrubber and particulate filters Projected performance Good organic destruction with no pretreatment requirements	Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems. Demonstration of a complete (continuous) pilot plant is scheduled for late 1994. Demonstration must include continuous feed and melt removal as well as successful preliminary chamber redesign for extended service.	Very high power requirements. This technology is far from commercial availability, but should be proven in 3-5 years. Unit operational costs are comparable to costs associated with a joule melter. Minimal feed preparation requirements make this the simplest of the thermal treatment options. It requires no segregation of the various components of this waste stream. Highest development risk of the thermal technologies. <u>Input waste stream characterization information needed</u> Characterization requirements may include the identification of volatile metals in this waste stream (see volatile metals in the characterization subelement beginning on page I-19). <u>Waste streams produced</u> Slag may be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see slag disposal beginning on page N-1). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page I-14). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page I-14). Mercury offgas (see mercury offgas under secondary waste streams beginning on page I-17).

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
→ Thermal Desorption → Retorting/roasting Low-temperature thermal unit in which mercury is vaporized for subsequent capture within the offgas. Options include desorber units (that are externally heated kilns) while other consituents are evacuated via batch waste systems. Volatilization of the other waste constituents is lower than in an incinerator, due to the lower process temperatures. The roaster offgases would be cooled to condense mercury and mercury compounds prior to capture within the offgas control device. A secondary combustion chamber is required for treatment of any volatile organics. The treated waste residue contains a large amount of carbon.	Accepted by industry. The EPA has approved this technology as the BDAT for high-mercury nonwastewaters. Subsystems required Feed pretreatment shredder for large items (as applicable) Small offgas treatment system, including offgas scrubber, mercury scrubber, and particulate filters Secondary combustion system (for treatment of volatilized organics) Solid residue handling system Mercury treatment system such as amalgamation Stabilization system for treatment residuals Projected performance Good organic destruction in secondary combustion Post-treatment stabilization of incinerator ash residues using cement is currently in wide use Long-term leaching performance is suspect Volume reduction is moderate Residual fixed carbon may impede solidification	Better characterization of waste stream to determine extent of volatilization of other waste consituents and whether the waste requires mixing during treatment, (to enable the exposure of all mercury-contaminated materials to the unit's processing temperatures). Determination of solidification requirements for roasted waste materials and the appropriate solidification agent to be used. Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems.	Normal implementation needs. Captured mercury and treatment residue will require treatment/stabilization prior to disposal. This technology and its subsystems are commercially available and are currently in use in the commercial sector but the large number of subsystems required make this technology relatively complicated and labor intensive. <u>Input waste stream characterization information needed</u> No specific characterization requirements for this waste stream. <u>Waste streams produced</u> Bottom ash that requires stabilization (see bottom ash under secondary waste streams beginning on page I-14). Flyash that requires stabilization (see flyash under secondary waste streams beginning on page I-14). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page I-14). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page I-14). Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1). Mercury offgas (see mercury offgas under secondary waste streams beginning on page I-17). An amalgamated mercury that can be disposed of as RCRA LLW (see solidified waste forms disposal beginning on page N-1).
→ Physical treatment via stabilization is applicable to waste streams classified as debris per the EPA debris rule → ALTERNATIVE - Solidification/Stabilization (combustible and small metal debris) → Sulfur Polymer Cement (SPC) Sulfur Polymer Cement is composed of 95% sulfur. It melts at approximately 110 to 120°C and is particularly applicable to the immobilization combustibles and small metal pieces.	SPC is being developed by the DOE for usage within this type of waste streams at INEL. SPC has been demonstrated on ash. SPC is not compatible with waste streams containing high nitrates. Subsystems required Waste feed system	Technology must be demonstrated on this waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The percent of sodium, potassium, sulfates,

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Sulfur Polymer Cement (SPC) (continued)	Ingredients feed system Shredder for combustibles and small metal pieces Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal		nitrates, and chlorides (see process residue salt content in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW) (see solidified waste forms disposal beginning on page N-1).
→ Chemically-bonded Ceramics (CbC) Chemically-bonded ceramic waste forms are produced by mixing the wastes and inorganic oxide binders together. The mixture is then processed at ambient and near ambient temperatures, promoting chemical reactions that bond the waste and the inorganic oxides into a dense ceramic material.	→ CbC is in the early stages for development by the DOE for usage on this type of waste streams. Subsystems required Waste feed system Ingredients feed system Shredder for combustibles and small metal pieces Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	→ Technology must be demonstrated on this waste stream.	→ Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The percent of sodium, potassium, sulfates, nitrates, and chlorides (see concentration of soluble salt in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Treatment
Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Secondary Waste Stream	Treatability Group
Bottom ash Carbon filters Flyash Mercury salts Offgas particulate filters Scrubber residue Sludge	Radiological Constituents: This waste may be classified as a waste containing 10-100 nCi/g of alpha-emitting radionuclides. However the waste may be classified as TRU waste, if the radionuclides in the waste feed become concentrated within the products generated by the treatment process. Contaminants: This waste stream is contaminated with toxic metals including cadmium, chromium, lead, and mercury. The following EPA-regulated wastes are suspected to be contained within the waste stream. F001:Halogenated solvents used in degreasing F002:Halogenated solvents and mixtures F006:Wastewater treatment sludges from electroplating Matrix: The waste matrix is ash, residues, filters, and mercury salts.

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
ALTERNATIVE - Solidification/Stabilization			
Polyethylene Polyethylene is an inert thermoplastic material that can be processed at low temperatures. Polyethylene binder and dry waste material are fed through separate calibrated volumetric or loss-in-weight feeders to an extruder. The materials are then thoroughly mixed, heated to a molten condition, and extruded into a suitable mold. On cooling, the mixture forms a solid monolithic waste form. No chemical reaction is required for solidification.	Polyethylene is being developed by the DOE for usage on these types of waste streams. Polyethylene has been demonstrated on scrubber residues. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and the compatibility of the process with the actual constituents contained in the waste stream. The technology needs development on the treatment of shredded particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input waste stream characterization information needed The percent of sodium, potassium, sulfates, nitrates, and chlorides (see concentration of soluble salt in the characterization subelement beginning on page M-12). Waste streams produced A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see solidified waste forms disposal beginning on page N-1).
Sulfur Polymer Cement (SPC) Sulfur Polymer Cement is composed of 95% sulfur. It melts at approximately 110 to 120°C and is particularly applicable to the immobilization combustibles and small metal pieces.	SPC is being developed by the DOE for usage within this type of waste streams at INEL. SPC has been demonstrated on ash. SPC is not compatible with waste streams containing high nitrates. Subsystems required Waste feed system Ingredients feed system Shredder for combustibles and small metal pieces. Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and the compatibility of the process with the actual constituents contained in the waste stream. The technology needs development on the treatment of shredded particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input waste stream characterization information needed The percent of sodium, potassium, sulfates, nitrates, and chlorides. (see concentration of soluble salt in the characterization subelement beginning on page M-12). Waste streams produced A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Alternative/Technology

Chemically-bonded Ceramics (CbC) →

Chemically-bonded ceramic waste forms are produced by mixing the wastes and inorganic oxide binders together. The mixture is then processed at ambient and near ambient temperatures, promoting chemical reactions that bond the waste and the inorganic oxides into a dense ceramic material.

Status

CbC is in the early stages for development by the DOE for usage on this type of waste streams. →

Subsystems required
- Waste feed system
- Ingredients feed system
- Shredder for combustibles and small metal pieces

Projected performance
- Expected to pass TCLP
- Expected to produce a suitable final waste form for disposal

Science and Technology Needs

Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and the compatibility of the process with the actual constituents contained in the waste stream. The technology needs development on the treatment of shredded particulate filters. →

Implementation Analysis

Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk.

Input waste stream characterization information needed

The percent of sodium, potassium, sulfates, nitrates, and chlorides (see concentration of soluble salt in the characterization subelement beginning on page M-12).

Waste streams produced

A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Secondary Waste Stream	Treatability Group
Mercury offgas	**Radiological Constituents:** This waste may be classified as waste containing 10-100 nCi/g of alpha-emitting radionuclides. However the waste may be classified as TRU waste, if the radionuclides in the waste feed become concentrated within the products generated by the treatment process. **Contaminants:** This waste is contaminated with toxic metals including cadmium, chromium, lead, and mercury. The following EPA-regulated wastes are suspected to be contained within the waste stream. F001:Halogenated solvents used in degreasing. F002:Halogenated solvents and mixtures F006:Wastewater treatment sludges from electroplating **Matrix:** This waste consists of an offgas stream.

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
ALTERNATIVE - Mercury Offgas Removal and Treatment			
Sodium Hypochlorite Injection; Cupric Chloride Injection; Carbon Adsorption The capture rate of mercury in the offgas utilizing only a wet scrubbing process may not be sufficient. If the concentration of the mercury in the waste is high, additional steps to remove mercury from the offgas may be necessary. Subjecting the offgas to a wet sodium hypochlorite or chelating agent/cupric chloride injection during the wet scrubbing process or subjecting the offgas to a carbon absorption following the wet scrubbing process will enable a greater capture rate of mercury. Mercury-contaminated carbon filters will have to be shredded and stabilized. Mercury-contaminated wet blowdown liquids will require chemical treatments such as chemical oxidation (to destroy the chelating agent if it is used), chemical reduction of toxic metals, and/or amalgamation of mercury (depending on the concentration of mercury and other metals contained within the blowdown). The slurry will then be dehydrated down to a sludge and treated via stabilization.	Accepted by industry. Subsystems required Feed pretreatment in treatment of volatile mercury System for mercury removal from carbon if encapsulation of charcoal with mercury is not acceptable for disposal Mercury treatment system such as amalgamation or chemical oxidation Projected performance High mercury removal efficiency at low cost Effective at removing trace quantities of other contaminants Simple to operate and maintain Potential problem with self-ignition on contact with oxygen	Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems. The issue of secondary treatment of the carbon/mercury residual or separation of the mercury from the carbon for final treatment and disposal needs to be resolved.	There are commercially available sorbent systems that must be demonstrated or applied to this application. Input waste stream characterization information needed: Concentrations of mercury in the waste (see concentration and chemical form of mercury in the characterization subelement beginning on page I-19). Waste streams produced Charcoal that is contaminated with mercury requires stabilization (see carbon filters under secondary waste streams beginning on page I-14).
Sodium Sulfide Injection Sodium sulfide is a crystalline solid that dissolves in water and is sprayed into the flue gas prior to acid gas removal. Lower concentrations, approximately 2% to 4% have been found to give better performance than higher concentrations. When used with municipal waste incineration, approximately 0.1 to 1 lb. of sodium sulfide is required per ton of waste.	Demonstration. New technology employed by a few operational facilities Subsystems required Feed pretreatment in treatment of volatile mercury System for residual treatment Projected performance Medium to high mercury removal Simple to operate Potential handling and deposition problems with sodium sulfide	Improvements needed in the atomization process to improve mass transfer effectiveness. Demonstration of this technology with respect to the treatment of this specific waste stream is needed. A treatment must also be developed to enable for proper disposal of the resulting residue.	Normal implementation needs. The technology is simple, but control and handling of the sodium sulfide requires care to prevent emission of sulfide fumes. Input waste stream characterization information needed Concentrations of mercury in the waste (see concentration and chemical form of mercury in the characterization subelement beginning on page I-19). Waste streams produced Mercury salts contaminated with radionuclides require stabilization (see mercury salts under secondary waste streams beginning on page I-14).

Mixed Waste Integrated Program

Logic Diagram

Oak Ridge
Y-12 Hazardous Solid Waste Characterization Technologies

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Characterization

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Concentration and chemical form of mercury.	Atomic Absorption, Cold-Vapor	Accepted. Samples must be converted to suitable solutions for analysis. EPA has approved the following methods for determining the total mercury (inorganic and organic) in solid wastes: EPA Method 245.5 - mercury (detection limit .0002 mg/L).	None. All samples must be subject to an appropriate dissolution step prior to analysis.	Method(s)/Instrument(s) available. Potassium permanganate is added to eliminate possible interference from sulfide. Wastes high in chloride require additional permanganate. Certain volatile organic absorb at the wavelength of mercury vapor (253.7 nm). A preliminary run without reagents should determine if this type of interference is present.
	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES' primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a consistent flow of sample to the instrument via the use of a peristolic pump, and/or the use of the standard additions method. EPA Method 200.7 - mercury (detection limit 0.02 mg/L).	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).
pH	Electrometric	Accepted and proven technology. This method (EPA Method 150.1) is applicable to aqueous wastes and is determined electrometrically using either a glass electrode in combination with a reference potential or a combination electrode. The	None.	Method(s)/Instrument(s) available. Off-the-shelf technology.

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Characterization

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Electrometric (continued)	pH can also be continuously monitored per EPA Method 150.2.		
Presence of dissolved salts (especially copper salts).	Atomic Absorption (AA), Furnace Technique	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following method to determine the concentration of copper in wastes: EPA Method 220.2 - copper (detection limit 1 ug/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Simultaneous background corrections must be made for all metals to avoid erroneously high results.
	Atomic Absorption (AA), Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following method for determining the concentration of copper metal in wastes: EPA Method 220.1 - copper (detection limit 0.02 mg/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required.
	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Characterization

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES) (continued)	a consistent flow of sample to the instrument via the use of a peristolic pump. and/or the use of the standard additions method. EPA Method 200.7 - silver (detection limit 0.003 mg/L)		
	→ Inductively-Coupled Plasma Mass Spectrometry (ICP-MS) →	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8). EPA Method 200.8 - silver (detection limit 0.03 ug/L) →	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation. →	Method(s)/Instrument(s) available.
	→ Ion Chromatography (IC) →	Accepted by EPA and industry. Ion Chromatography (EPA Method 300.0) is able to quickly and accurately determine anions in solution to ppm or ppb concentrations. In order to use IC for solids, an extraction method outlined in EPA Method 300.0 must be performed. Additional separation techniques may be needed to further separate ionic species. EPA Method 300.0 - fluoride (detection limit 0.01 mg/L) EPA Method 300.0 - chloride (detection limit 0.02 mg/L) EPA Method 300.0 - nitrate (detection limit 0.002-0.004 mg/L) EPA Method 300.0 - sulfate (detection limit 0.02 mg/L) →	None, with proper sample preparation. →	Instrument(s) available.
Chemical Oxygen Demand (COD) analysis. →	Chemical Oxygen Demand (COD) determines the quantity of oxygen required to oxidize the organic matter in a waste sample, under specific conditions of oxidizing agent, temperature and time. There is no technology per se to determine COD. However, EPA has developed laboratory procedures to determine COD of waste material. These procedures are:			

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Characterization

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Chemical Oxygen Demand (continued)	EPA Method 410.1 (Titrimetric, Mid-Level) EPA Method 410.2 (Titrimetric, Low-Level) EPA Method 410.3 (Titrimetric, High-Level for Saline Waters) EPA Method 410.4 (Colorimetric, Automated; Manual)			
Metal salts (especially silver salts)	Atomic Absorption (AA), Furnace Technique	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following method to determine the concentration of silver in wastes: EPA Method 272.2 - silver (detection limit 0.2 ug/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Simultaneous background corrections must be made for all metals to avoid erroneously high results.
	Atomic Absorption (AA), Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following method for determining the concentration of silver metal in wastes: EPA Method 273.1 - silver (detection limit 0.002 mg/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required.
	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Characterization

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (continued)	inaccuracies. This can be reduced by diluting the sample using a peristolic pump, or by using the standard additions method. EPA Method 200.7 - silver (detection limit 0.002 mg/L)		
	Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8). EPA Method 200.8 - silver (detection limit 0.05 ug/L)	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s)/Instrument(s) available.
	Ion Chromatography (IC)	Accepted by EPA and Industry. Ion Chromatography (EPA Method 300.0) is able to quickly and accurately determine anions in solution to ppm or ppb concentrations. In order to use IC for solids, an extraction method outlined in EPA Method 300.0 must be performed. Additional separation techniques may be needed to further separate ionic species. EPA Method 300.0 - fluoride (detection limit 0.01 mg/L) EPA Method 300.0 - chloride (detection limit 0.02 mg/L) EPA Method 300.0 - nitrate (detection limit 0.002-0.004 mg/L) EPA Method 300.0 - sulfate (detection limit 0.02 mg/L)	None, with proper sample preparation.	Instrument(s) available. Estimated capital costs: $30K. Estimated cost per analysis: $25-$50.

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Characterization

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Cyanide	Titration	Accepted by EPA. This technique (EPA Method 335.2) is applicable to the determination of total cyanide in aqueous wastes. The cyanide as hydrocyanic acid (HCN) is released from cyanide complexes by means of a reflux-distillation operation and absorbed in a scrubber containing sodium hydroxide solution. The cyanide ion in the absorbing solution is then determined by volumetric titration or colorimetrically. The estimated minimum amount of cyanide detected by this method is 0.02 mg/L.	None. Proven technology.	Method(s)/Instrument(s) available. Sulfides adversely affect the colorimetric procedure. However, if sulfides are present, they can be precipitated out of the sample.
	Colorimetry, Automated UV	Accepted by EPA. This technique (EPA Method 335.3) is applicable to the determination of total cyanide in aqueous wastes. The cyanide as hydrocyanic acid (HCN) is released from cyanide complexes by means of UV digestion and distillation. Cyanides are converted to cyanogen chloride by reactions with chloramine-T which subsequently reacts with pyridine and barbituric acid to give a red-colored complex. The estimated minimum amount of cyanide detected by this method is 5 ug/L.	None. Proven technology.	Method(s)/Instrument(s) available. Sulfides adversely affect the colorimetric procedure. However, if sulfides are present, they can be precipitated out of the sample.
PCBs.	Gas Chromatography/Mass Spectrometry (GC/MS)	Accepted by EPA. Gas chromatography-mass spectrometry (GC-MS) is a technique which provides separation of volatile and semi-volatile organic molecules by gas chromatography and detection by mass spectrometry. Utilizes the separation characteristics of various chromatographic columns, qualitative and quantitative data are obtained by correlating masses detected with the elution times. EPA Method 680 - PCBs in soil/sediment by GCMS.	None. Technology is applicable as is. Benefit would be derived from faster chromatography to shorten analysis time.	Method(s)/Instrument(s) available. Mature technology.

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Characterization

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Volatile metals (such as arsenic, mercury, cadmium, selenium, and lead).	Atomic Absorption (AA), Furnace Technique	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.0). EPA has approved the following methods for determining the concentration of volatile metals in wastes: EPA Method 206.2 - arsenic (detection limit 1 ug/L) EPA Method 213.2 - cadmium (detection limit 0.1 ug/L) EPA Method 270.2 - selenium (detection limit 2 ug/L) EPA Method 239.2 - lead (detection limit 1 ug/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Arsenic and selenium analysis can suffer from severe nonspecific absorption and light scattering by matrix components during atomization due to their low analytical wavelengths. Simultaneous background corrections must be made for all metals to avoid erroneously high results.
	Atomic Absorption (AA), Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.0). EPA has approved the following methods for determining the concentration of volatile metals in wastes: EPA Method 213.1 - cadmium (detection limit 0.005 mg/L) EPA Method 239.1 - lead (detection limit 0.1 mg/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required. For concentrations of cadmium below 0.02 mg/L, the furnace procedure (EPA Method 213.2) is recommended. For concentrations of lead below 0.2 mg/L, the furnace procedure (EPA Method 239.2) is recommended.
	Atomic Absorption, Cold-Vapor	Accepted. Samples must be converted to suitable solutions for analysis. EPA has approved the following methods for determining the total mercury (inorganic and organic) in solid wastes: EPA Method 245.5 - mercury (detection limit .0002 mg/L)	None. All samples must be subject to an appropriate dissolution step prior to analysis.	Method(s)/Instrument(s) available. Potassium permanganate is added to eliminate possible interference from sulfide. Wastes high in chloride require additional permanganate. Certain volatile organic absorb at the wavelength of mercury vapor (253.7 nm). A preliminary run without reagents should determine if this type of interference is present.
	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analy-	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see

Mixed Waste Integrated Program Logic Diagram

Name: Y-12 Hazardous Solid Waste **MWIR#:** 919 **Subelement:** Characterization

Matrix: Inorganic Debris / 5430 **Site:** Oak Ridge

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	(Continuation of Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry)	sis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a consistent flow of sample to the instrument via the use of a peristolic pump, and/or the use of the standard additions method. EPA Method 200.7 - arsenic (detection limit 0.008 mg/L) EPA Method 200.7 - mercury (detection limit 0.02 mg/L) EPA Method 200.7 - cadmium (detection limit 0.001 mg/L) EPA Method 200.7 - selenium (detection limit 0.02 mg/L) EPA Method 200.7 - lead (detection limit 0.01 mg/L)		Table 2, EPA Method 200.7).
	Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8). EPA Method 200.8 - arsenic (detection limit 0.9 ug/L) EPA Method 200.8 - cadmium (detection limit 0.1 ug/L) EPA Method 200.8 - selenium (detection limit 5 ug/L) EPA Method 200.8 - lead (detection limit 0.08 ug/L)	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s)/Instrument(s) available.

Mixed Waste Integrated Program

Logic Diagram

Rocky Flats
Saltcrete
Treatment Technologies

Mixed Waste Integrated Program Logic Diagram

Name: Saltcrete **MWIR#:** 340 **Subelement:** Treatment

Matrix: Solidified Process Residues / 3150 **Site:** Rocky Flats

Waste Stream

Waste Stream Description

This waste stream consists of solvents (both halogenated and non-halogenated), toxic heavy metals such as cadmium, chromium and silver. Cyanide is above the LDR Standard.

Problems Presented by Waste Stream

The lack of characterization with regard to organic and TCLP metal analysis forces some assumptions in order to select technology options. Waste materials are in the form of cement blocks contained within 2'x4'x7' boxes (either poured directly into the box or loosely placed). Prior to 1990 high waste loading (55 wt.%) yielded a waste form that wasn't always well mixed. The size and weight of these boxes presents handling concerns. This waste material was generated through the solidification of the concentrate from an evaporation process at the Liquid Waste Treatment Facility in Building 374. Thermal treatment of this waste may generate large quantities of NOx in the offgas that will require removal. The presence of solvents and cyanides in some of the waste requires a destruction technology, such as incineration. The likelihood of heavy metal contamination in excess of TCLP limits dictates the immobilization of the waste, based on the currently available analytical information.

The solidified nature of the waste via Portland cement presents the biggest problem for treatment. A portion of the solidified waste forms will require shredding, crushing, and grinding prior to any potential subsequent treatments, to ensure that all radionuclides and hazardous materials can be destroyed or isolated.

Treatability Group

Radiological Constituents:
This waste is classified as contact-handled with 10 - 100 nCi/g of alpha contamination.

Contaminants:
This waste stream is contaminated with halogenated and non-halogenated solvents, toxic heavy metals such as cadmium, chromium, and silver. Cyanide is above LDR standard. The following EPA regulated wastes are suspected to be contained within the waste stream.

F001:Halogenated solvents used for degreasing
F002:Halogenated solvents and mixtures
F003:Non-halogenated solvents
F005:Non-halogenated solvents and mixtures
F006:Wastewater treatment sludges from electroplating
F007:Spent cyanide plating bath solutions
F009:Spent stripping and cleaning bath solutions from electroplating operations

Matrix:
This waste consists of solidified process residues.

Mixed Waste Integrated Program Logic Diagram

Name: Saltcrete **MWIR#:** 340 **Subelement:** Treatment

Matrix: Solidified Process Residues / 3150 **Site:** Rocky Flats

Alternative/Technology

CHEMICAL TREATMENT

Although chemical treatment could be applicable to this waste stream, it was dismissed because of the waste stream's estimated large volume, ~3000 m^3. The high-cement content of the waste equates to a high pH within the material. Chemical separation and treatment of this waste would require excessive dilution, leading to the creation of a large amount of secondary wastes that would also require treatment.

THERMAL TREATMENT

ALTERNATIVE - Incineration (calcination)

Rotary Kiln

Cylindrical refractory-lined shell mounted on a slight incline; rotation of the kiln moves the non-containerized waste through while enhancing mixing. Dehydration of this waste will occur resulting in the calcination of the waste materials. A high-temperature secondary combustion chamber is also required to complete organic vapor destruction.

Potential high-temperature volatilization of cadmium may require the subsequent capture of the metal in the incinerator offgas. The incinerator offgases would be subsequently cooled in order to condense this metal (or compounds) prior to being entrained via a particulate removal device. The wooden box would be burned in the kiln. Rotary kilns cannot be used in-service via routine thermal cycling.

Status

Accepted by industry. EPA has approved this technology as the BDAT for organics, as well as cyanide. DOE is currently operating a rotary kiln at the Oak Ridge K-25 site. With the likelihood that the cement waste will calcine, high dust- loading to the offgas system is likely. The offgas system will need to be designed to handle large quantities of dust.

Subsystems required
- Feed pretreatment crusher
- Wooden box shredder
- Large offgas treatment system, including a dry off-gas scrubber, and particulate filters to handle high dust loading
- Ash handling system
- Stabilization system for treatment residuals

Projected performance
- Good organic destruction (as well as cyanides)
- Rotating kiln seals questionable for contamination control
- Post-treatment stabilization of ash residuals using cement is currently in wide use
- Long-term leaching performance is suspect
- Volume reduction is moderate; alternate stabilization techniques possible for better long-term performance
- Calcination of the cemented waste material may lower the overall performance by making the off-gas system prone to flow obstructions

Science and Technology Needs

Better characterization of the waste stream to determine the extent of volatilization of other waste constituents. Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems.

Implementation Analysis

Captured metals and treatment residue will require treatment/stabilization prior to disposal. The rotary kiln incineration technology is commercially available and currently used within the commercial sector. The technology is currently in use within the DOE sector for non-cemented sludge wastes. The required subsystems, as described above, are commercially available. The moving parts and large number of subsystems required make this technology relatively complicated and labor intensive.

Input waste stream characterization information needed

Characterization requirements may include the identification of volatile metals in the waste stream. (see volatile metals in the characterization subelement beginning on page J-10).

Waste streams produced

Bottom ash that requires stabilization (see bottom ash under secondary waste streams beginning on page J-7).

Flyash that requires stabilization (see flyash under secondary waste streams beginning on page J-7).

Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page J-7).

Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page J-7).

Empty containers that can be disposed of as LLW

Mixed Waste Integrated Program Logic Diagram

Name: Saltcrete **MWIR#:** 340 **Subelement:** Treatment

Matrix: Solidified Process Residues / 3150 **Site:** Rocky Flats

Alternative/Technology

Rotary Kiln (continued)

ALTERNATIVE - Vitrification

Joule Heated Melter

Refractory-lined reactor in which a pool of glass is maintained molten by joule heating; size-reduced waste is introduced into the glass pool and dissolved into the glass matrix. High-temperature volatilization of cadmium requires the subsequent capture of the metal in the incinerator offgas. The incinerator offgases would be subsequently cooled in order to allow these metals (or compounds) to condense prior to being entrained via a particulate removal device. Salt content of the waste may require the addition of significant volumes of glassification agents, such as phosphate modifiers.

Status

Ready for demonstration

Subsystems required
- Waste shredder or grinder and system to reduce waste size
- Waste feed system
- Glass additive feed system
- Molten glass handling system
- Secondary combustion chamber
- Small offgas treatment system, including acid-gas scrubber, metal-recovery system, and particulate filter

Projected performance
- Good organic destruction requires reduction of the organics via pretreatment or extended residence time within the melt
- Need to tightly control melt chemistry which may complicate operation
- Offgas system flyash can be processed through the melter
- Addition of glass formers necessary to maintain viscosity limits; otherwise excellent volume reduction
- Highly stable glass final waste form

Science and Technology Needs

Technology must be demonstrated on this waste stream, including operation of required subsystems.

Implementation Analysis

(see empty containers disposal beginning on page N-1).

High power requirements. This technology will be commercially available for waste applications within 2 years, and is currently in use for highly specialized applications in the DOE system. Unit operational costs and life-cycle costs fall in the mid-range of this group of technologies. Large number of subsystems required and the need to carefully control melt chemistry, make this technology relatively complicated. Medium development risk compared to all of the other thermal technologies.

Input waste stream characterization information needed

Characterization requirements may include the identification of volatile metals (see volatile metals in the characterization subelement beginning on page J-10) and vitrification qualities due to salt content of this waste stream. Salts are expected to be comprised of potassium, calcium, and sodium. (see salt content in the characterization subelement beginning on page J-10).

Waste streams produced

Stabilized glass can be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see stabilized glass disposal beginning on page N-1).

Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page J-7).

Empty boxes can be disposed of a LLW (see empty containers disposal beginning on page N-1).

Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page J-7).

Mixed Waste Integrated Program Logic Diagram

Name: Saltcrete **MWIR#:** 340 **Subelement:** Treatment

Matrix: Solidified Process Residues / 3150 **Site:** Rocky Flats

Plasma Arc Furnace

Alternative/Technology

Plasma Arc Furnace

Refractory-lined chamber into which unopened, containerized waste is introduced and melted in the high-temperature arc of a plasma torch. High-temperature volatilization of cadmium requires the subsequent capture of the metal in the incinerator offgas. The offgases would be subsequently cooled in order to allow this metal (or compounds) to condense prior to being entrained via a particulate removal device. A secondary combustion chamber for treatment of organics is commonly included. Dual melter tests are currently indicating stabilization additives may be necessary, due to the waste stream's sulfate content.

Status

Large scale pilot demonstration of a batch-feed system is complete. A continuous pilot-plant demonstration is scheduled for late 1994.

Subsystems required
- Waste feed system (with size reduction)
- molten material handling system
- Secondary combustion chamber
- Offgas treatment system, including offgas scrubber and particulate filters
- Possible need for additive feed system

Projected performance
- Highest temperature range, good organic destruction with no pretreatment expected
- Good volume reduction
- Highly stable slag waste form
- Offgas system particulate filters and flyash can be processed through the furnace

Science and Technology Needs

The technology has been demonstrated in a nearly full scale system using a batch feed mode. Technology must be demonstrated on this waste stream, including operation of required subsystems. Treatability testing is required with the likelihood that additives will be required.

Implementation Analysis

High power requirements. This technology is the furthest from being commercially available, but should be proven in 3-5 years. Unit operational costs are comparable to joule melter. The technology can process this waste stream with only size modification of the waste. Highest development risk of all of the thermal technologies.

Input waste stream characterization information needed

Characterization requirements may include the identification of volatile metals in the waste stream in this technology. (see volatile metals in the characterization subelement beginning on page J-10).

Waste streams produced

Slag may be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see slag disposal beginning on page N-1).

Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page J-7).

Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page J-7).

ALTERNATIVE - Thermal Desorption

Retorting/roasting

Alternative/Technology

Retorting/roasting

Low-temperature thermal unit in which volatile and nonvolatile organics are volatilized or decomposed. Options include desorber units that are externally heated kilns, while others are evacuated batch waste systems. Volatilization of the other waste constituents occurs less frequently than in an incinerator due to the lower processing temperatures. The use of the thermal desorption technology would eliminate the generation of NOx and thus reduce additional subsystems for offgas scrubbing. A secondary combustion chamber is required for treatment of the volatile organics.

Status

Accepted by industry.

Subsystems required
- Feed pretreatment crusher
- Wooden box shredder
- Moderate offgas treatment system, including offgas scrubber, and particulate filters
- Secondary combustion system (for treatment of volatilized organics)
- Solid residue handling system
- Stabilization system for treatment residuals

Projected performance
- Good organic destruction in secondary combustor
- Post-treatment stabilization of waste residues using cement is currently in wide use
- Long-term leaching performance is suspect
- Residual salts will impede solidification

Science and Technology Needs

Better characterization of waste stream, to determine extent of volatilization of any waste constituents, and whether waste requires mixing during processing to expose all contaminated materials to the processing unit temperatures. Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems. A waste-specific treatability study is necessary. Determination of solidification requirements for roasted waste materials and the identification of an appropriate solidification agent would be part of the treatability study.

Implementation Analysis

Normal implementation needs. Treatment residue will require treatment/stabilization prior to disposal. This technology and its subsystems are commercially available and are currently in use in the commercial sector for this waste type. The large number of subsystems required make this technology relatively complicated and labor intensive.

Input waste stream characterization information needed

No specific characterization requirements for this waste stream.

Waste streams produced

Treated solid residue requires stabilization (see treated solid residue under secondary waste streams beginning on page J-7).

Flyash that requires stabilization (see flyash under

Mixed Waste Integrated Program Logic Diagram

Name: Saltcrete **MWIR#:** 340 **Subelement:** Treatment

Matrix: Solidified Process Residues / 3150 **Site:** Rocky Flats

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Retorting/roasting (continued)			secondary waste streams beginning on page J-7). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page J-7). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page J-7). Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: Saltcrete **MWIR#:** 340 **Subelement:** Treatment

Matrix: Solidified Process Residues / 3150 **Site:** Rocky Flats

Secondary Waste Stream	Treatability Group
Bottom ash Flyash Offgas particulate filters Scrubber residue Treated solid residue	Radiological Constituents: This waste may be classified as a waste containing 10-100 nCi/g of alpha-emitting radionuclides. However the waste may be classified as TRU waste, if the radionuclides in the waste feed become concentrated within the products generated by the treatment process. Contaminants: This waste stream is contaminated with toxic heavy metals such as cadmium, chromium, and silver. The following EPA regulated wastes are suspected to be contained within the waste stream. F001:Halogenated solvents used for degreasing F002:Halogenated solvents and mixtures F003:Non-halogenated solvents F005:Non-halogenated solvents and mixtures F006:Wastewater treatment sludges from electroplating F007:Spent cyanide plating bath solutions F009:Spent stripping and cleaning bath solutions from electroplating operations Matrix: This waste consists of ash, solid residues, scrubber residue, and particulate filters.

Mixed Waste Integrated Program Logic Diagram

Name: Saltcrete **MWIR#:** 340 **Subelement:** Treatment

Matrix: Solidified Process Residues / 3150 **Site:** Rocky Flats

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
ALTERNATIVE Solidification/Stabilization			
Polyethylene Polyethylene is an inert thermoplastic material that can be processed at low temperatures. Polyethylene binder and dry waste material are fed through separate calibrated volumetric or loss-in-weight feeders to an extruder. The materials are then thoroughly mixed, heated to a molten condition, and extruded into a suitable mold. On cooling, the mixture forms a solid monolithic waste form. No chemical reaction is required for solidification.	Polyethylene is being developed by DOE for use in these types of waste streams. Polyethylene has been demonstrated on scrubber residues. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual waste streams. The technology needs development on the treatment of shredded particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates,and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see solidified waste forms disposal beginning on page N-1).
Sulfur Polymer Cement (SPC) Sulfur Polymer Cement is composed of 95% sulfur. It melts at approximately 110 to 120°C and is particularly applicable to the immobilization of toxic metals and treatment of incinerator ash.	SPC is being developed by DOE for use in these types of waste streams. SPC has been demonstrated on ash. SPC is not compatible with high nitrates. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual waste streams. The technology needs development on the treatment of shredded particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates,and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see solidified waste forms disposal beginning on page N-1).
Chemically-bonded Ceramics (CbC) - Chemically-bonded ceramic waste forms are produced by mixing the wastes and inorganic oxide	CbC is in early stages for development by DOE for use in these types of waste streams.	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual waste streams. The	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk.

Mixed Waste Integrated Program Logic Diagram

Name: Saltcrete **MWIR#:** 340 **Subelement:** Treatment
Matrix: Solidified Process Residues / 3150 **Site:** Rocky Flats

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
binders together. The mixture is then processed at ambient and near ambient temperatures, promoting chemical reactions that bond the waste and the inorganic oxides into a dense ceramic material.	Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	technology needs development on the treatment of shredded particulate filters.	Input waste stream characterization information needed The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). Waste streams produced A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program

Logic Diagram

Rocky Flats
Saltcrete
Characterization Technologies

Mixed Waste Integrated Program Logic Diagram

Name: Saltcrete **MWIR#:** 340 **Subelement:** Characterization

Matrix: Solidified Process Residues / 3150 **Site:** Rocky Flats

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Volatile metals - cadmium.	Alternative/Technology Atomic Absorption (AA), Furnace Technique	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following method for determining the concentration of cadmium in the waste: EPA Method 213.2 - cadmium (detection limit 0.1 ug/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Arsenic and selenium analysis can suffer from severe nonspecific absorption and light scattering by matrix components during atomization due to their low analytical wavelengths. Simultaneous background corrections must be made for all metals to avoid erroneously high results.
	Alternative/Technology Atomic Absorption (AA), Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following method for determining the concentration of cadmium metal in the waste: EPA Method 213.1 - cadmium (detection limit 0.005 mg/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required. For concentrations of cadmium below 0.02 mg/L, the furnace procedure (EPA Method 213.2) is recommended.
	Alternative/Technology Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES's primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a consistent flow of sample to the instru-	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).

Mixed Waste Integrated Program Logic Diagram

Name: Saltcrete **MWIR#:** 340 **Subelement:** Characterization

Matrix: Solidified Process Residues / 3150 **Site:** Rocky Flats

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (continued)	ment via the use of a peristolic pump, and/or by the use of the standard additions method. EPA Method 200.7 - cadmium (detection limit 0.001 mg/L)		
	Alternative/Technology Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8). EPA Method 200.8 - cadmium (detection limit 0.1 ug/L)	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s)/Instrument(s) available.
Salt content (salts are primarily potassium, calcium, and sodium).	Alternative/Technology Atomic Absorption, Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following methods for determining the concentration of potassium and sodium in wastes: EPA Method 258.1 - potassium (detection limit 0.01 mg/L) EPA Method 273.1 - sodium (detection limit 0.002 mg/L) EPA Method 215.1 - calcium (detection limit 0.01 mg/L)	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required.
	Alternative/Technology Ion Chromatography (IC)	Accepted by EPA and industry. Ion Chromatography (EPA Method 300.0) is able to quickly and accurately determine anions in solution to ppm or ppb concentrations. In order to use IC for solids, an extraction method outlined in EPA Method 300.0 must be performed. Additional separation techniques may be needed to further separate ionic species. EPA Method 300.0 - fluoride (detection limit 0.01 mg/L)	None, with proper sample preparation.	Instrument(s) available.

Mixed Waste Integrated Program Logic Diagram

Name: Saltcrete **MWIR#:** 340 **Subelement:** Characterization

Matrix: Solidified Process Residues / 3150 **Site:** Rocky Flats

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Ion Chromatography (IC) (continued)	EPA Method 300.0 - chloride (detection limit 0.02 mg/L) EPA Method 300.0 - nitrate (detection limit 0.002-0.004 mg/L) EPA Method 300.0 - sulfate (detection limit 0.02 mg/L)		
	Alternative/Technology Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES's primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a consistent flow of sample to the instrument via the use of a peristolic pump, and/or by the use of the standard additions method. EPA Method 200.7 - potassium (detection limit 0.3 mg/L) EPA Method 200.7 - sodium (detection limit 0.03 mg/L) EPA Method 200.7 - calcium (detection limit 0.01 mg/L)	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).

Mixed Waste Integrated Program Logic Diagram

Name: Saltcrete **MWIR#:** 340 **Subelement:** Characterization

Matrix: Solidified Process Residues / 3150 **Site:** Rocky Flats

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Alternative/Technology Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8).	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s)/Instrument(s) available.

Mixed Waste Integrated Program

Logic Diagram

Savannah River
Cadmium Contaminated Glovebox
Treatment Technologies

Mixed Waste Integrated Program Logic Diagram

Name: Cadmium Contaminated Glovebox **MWIR#:** 2703 **Subelement:** Treatment
Matrix: Cadmium Contaminated Metal Debris / 5430 **Site:** Savannah River

Waste Stream	Treatability Group
Waste Stream Description This waste stream consists of toxic heavy metals including: cadmium. Problems Presented by Waste Stream The waste was generated from decommissioning operations of a glovebox. Part of a glovebox being decommissioned was contaminated with a cadmium solution previously. The glovebox piece is now located in a drum in a satellite area. LDR treatment for the identified waste is stabilization.	Radiological Constituents: This waste is classified as contact-handled with 10 - 100 nCi/g of alpha contamination. Contaminants: This waste stream is contaminated with the toxic heavy metal cadmium. D006: Cadmium Matrix: This waste consists of cadmium contaminated metal debris.

Mixed Waste Integrated Program Logic Diagram

Name: Cadmium Contaminated Glovebox **MWIR#:** 2703 **Subelement:** Treatment

Matrix: Cadmium Contaminated Metal Debris / 5430 **Site:** Savannah River

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
THERMAL TREATMENT Due to the volatile characteristic of cadmium, thermal treatment is not deemed an appropriate treatment technique.			
CHEMICAL TREATMENT ALTERNATIVE: Decontamination			
Acidic rinse Decontamination of the glove box with a dilute acid rinse will transfer the cadmium contamination from the glovebox to the acidic solution. The acidic solution can then be neutralized and dehydrated down to the consistency of a sludge.	Decontamination via acidic rinse is a standard technology used by industry to remove heavy metals from metal substrates. Subsystems required Acid rinse system Neutralization system Dehydration system Projected performance Expected to produce a product that can be stabilized into a final waste form for disposal	None required.	Simple treatment system makes this waste easy to decontaminate. Although, the presence of acid in an alpha-contaminated environment may present safety problems. <u>Input Waste Stream Characterization Information Needed</u> None required. <u>Waste Streams Produced</u> Cadmium oxide, sulfate, chloride, or hydroxide solid/sludge residue (see sludge under secondary waste streams beginning on page K-5). Decontaminated glovebox part or parts can be disposed of as LLW (see metal debris disposal beginning on page N-1).
PHYSICAL TREATMENT ALTERNATIVE: Decontamination			
CO2 Blasting CO2 Blasting is the blasting away of contaminants (metal and/or organic) from the surfaces of metal and plastic debris. Frozen CO2 is pelletized and sprayed via high-pressure at the surface of the debris. The CO2 evaporates and the contaminants are discharged onto the floor of the room. The contaminants can then be swept up off of the floor and treated via stabilization and disposed of. No secondary wastes are produced.	Technology has been previously demonstrated on waste streams of similar types. Airline manufacturers such as McDonnell Douglas use this method to strip paint from airplanes, while firms such as Westinghouse use this method to decontaminate radioactive equipment. Subsystems required CO2 pelletizer Internal dryer Air compressor Liquid CO2 tank Projected performance Expected to produce a product that can be stabilized into a final waste form for disposal	None required.	Medium power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. High-pressure within an alpha environment may present a safety problem. <u>Input waste stream characterization information needed</u> None required. <u>Waste streams produced</u> A particulate waste form that requires solidification (see particulate under secondary waste streams beginning on page K-5). Decontaminated glovebox part or parts can be disposed of as LLW (see metal debris disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: Cadmium Contaminated Glovebox **MWIR#:** 2703 **Subelement:** Treatment

Matrix: Cadmium Contaminated Metal Debris / 5430 **Site:** Savannah River

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Polyethylene Bead Blasting Polyethylene Bead Blasting is the blasting away of contaminants (metal and/or organic) from the surfaces of metal and plastic debris. Polyethylene material is pelletized and sprayed via high-pressure upon the surface of the debris. The impact of the pellets on the debris causes the removal of the contamination from the surface of the debris. The contamination may be attached to the pellets or may lay as particulate upon the floor. The contaminants can then be swept up off of the floor and treated via polyethylene encapsulation and disposed of.	Technology has been previously demonstrated on waste streams of similar types. This method has been successfully used in the past at Hill Air Force Base to remove contamination from metal parts. Subsystems required Polyethylene pelletizer Air compressor See also polyethylene encapsulation stabilization treatment requirements Projected performance Expected to produce a product that can be stabilized into a final waste form for disposal	None required.	Medium-power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. High-pressure within an alpha-contaminated environment may present a safety problem. Input waste stream characterization information needed None required. Waste streams produced A particulate waste form that requires solidification (see particulate under secondary waste streams beginning on page K-5). Decontaminated glovebox part or parts can be disposed of as LLW (see metal debris disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: Cadmium Contaminated Glovebox **MWIR#:** 2703 **Subelement:** Treatment

Matrix: Cadmium Contaminated Metal Debris / 5430 **Site:** Savannah River

Secondary Waste Stream	Treatability Group
Particulate Sludge	**Radiological Constituents:** This waste may be classified as waste containing 10-100 nCi/g of alpha-emitting radionuclides. However the waste may be classified as TRU waste, if the radionuclides in the waste feed become concentrated within the products generated by the treatment process. **Contaminants:** This waste stream is contaminated with the toxic heavy metal cadmium. **Matrix:** This waste consists of sludge residues and particulate matter.

Mixed Waste Integrated Program Logic Diagram

Name: Cadmium Contaminated Glovebox **MWIR#:** 2703 **Subelement:** Treatment

Matrix: Cadmium Contaminated Metal Debris / 5430 **Site:** Savannah River

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
ALTERNATIVE - Solidification/Stabilization			
Polyethylene Polyethylene is an inert thermoplastic material that can be processed at low temperatures. Polyethylene binder and dry waste material are fed through separate calibrated volumetric or loss-in-weight feeders to an extruder. The materials are then thoroughly mixed, heated to a molten condition, and extruded into a suitable mold. On cooling, the mixture forms a solid monolithic waste form. No chemical reaction is required for solidification.	The polyethylene encapsulation process is being developed by the DOE for usage on these types of waste streams. Subsystems required Waste feed system Ingredients feed system Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual constituents contained in the waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> Amounts of cadmium, sulfates, chlorides, and hydroxides (see amounts of cadmium, sulfates, chlorides, and hydroxides in the characterization subelement beginning on page K-8). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).
Sulfur Polymer Cement (SPC) Sulfur Polymer Cement is composed of 95% sulfur. It melts at approximately 110 to 120°C and is particularly applicable to the immobilization of toxic metals and treatment of incinerator ash.	SPC is being developed by the DOE for usage within these types of waste streams. Subsystems required Waste feed system Ingredients feed system Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual constituents contained in the waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> Amounts of cadmium, sulfates, chlorides, and hydroxides (see amounts of cadmium, sulfates, chlorides, and hydroxides in the characterization subelement beginning on page K-8). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).
Chemically-bonded Ceramics (CbC) - Chemically-bonded ceramic waste forms are produced by mixing the wastes and inorganic oxide binders together. The mixture is then processed at ambient and near ambient temperatures, promoting chemical reactions that bond the waste and the inorganic oxides into a dense ceramic material.	The CbC process is in the early stages of development by the DOE usage with these types of waste streams. Subsystems required Waste feed system Ingredients feed system Projected performance Expected to pass TCLP	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual constituents of the waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> Amounts of cadmium, sulfates, chlorides, and hydroxides (see amounts of cadmium, sulfates, chlorides, and hydroxides in the characterization subelement beginning on page K-8).

Mixed Waste Integrated Program Logic Diagram

Name: Cadmium Contaminated Glovebox **MWIR#:** 2703 **Subelement:** Treatment

Matrix: Cadmium Contaminated Metal Debris / 5430 **Site:** Savannah River

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Chemical-bonded Ceramics (continued)	Expected to produce a suitable final waste form for disposal		Waste streams produced A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program

Logic Diagram

Savannah River
Cadmium Contaminated Glovebox
Characterization Technologies

Mixed Waste Integrated Program Logic Diagram

Name: Cadmium Contaminated Glovebox **MWIR#:** 2703 **Subelement:** Characterization

Matrix: Cadmium Contaminated Metal Debris / 5430 **Site:** Savannah River

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Amounts of cadmium, sulfates, chlorides, and hydroxides.	Atomic Absorption (AA), Furnace Technique	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following method to determine the concentration of cadmium metal in wastes: EPA Method 213.2 - cadmium (detection limit 0.1 ug/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Simultaneous background corrections must be made for all metals to avoid erroneously high results.
	Atomic Absorption (AA), Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following method for determining the concentration of cadmium metal in wastes: EPA Method 213.1 - cadmium (detection limit 0.005 mg/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required. For concentrations of cadmium below 0.02 mg/L, the furnace procedure (EPA Method 213.2) is recommended.
	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a consistent flow of sample to the instrument via the use of a peristolic pump.	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).

Mixed Waste Integrated Program Logic Diagram

Name: Cadmium Contaminated Glovebox **MWIR#:** 2703 **Subelement:** Characterization

Matrix: Cadmium Contaminated Metal Debris / 5430 **Site:** Savannah River

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	(Continuation of Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry)	and/or by the use of the standard additions method. EPA Method 200.7 - cadmium (detection limit 0.001 mg/L)		
	Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8). EPA Method 200.8 - cadmium (detection limit 0.1 ug/L)	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s)/Instrument(s) available.
	Ion Chromatography (IC)	Accepted by EPA and industry. Ion Chromatography (EPA Method 300.0) is able to quickly and accurately determine anions in solution to ppm or ppb concentrations. In order to use IC for solids, an extraction method outlined in EPA Method 300.0 must be performed. Additional separation techniques may be needed to further separate ionic species. EPA Method 300.0 - chloride (detection limit 0.02 mg/L) EPA Method 300.0 - sulfate (detection limit 0.02 mg/L)	None, with proper sample preparation.	Instrument(s) available.

Mixed Waste Integrated Program

Logic Diagram

Savannah River
SRS Thirds Waste
Treatment Technologies

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919

Matrix: Heterogeneous Debris / 5400

Subelement: Treatment

Site: Savannah River

Waste Stream

Waste Stream Description

This waste stream contains heavy metals, including beryllium and mercury, and organics. It is ignitable and reactive.

Problems Presented by Waste Stream

Waste generated primarily through activities in the course of plutonium production. Includes small amounts of TRU waste from on-site laboratories. These wastes are primarily solids consisting of booties, lab coats, floor sweepings, and rags.

LDR treatment requirements for the waste codes listed include incineration, vitrification, chemical reduction, acid leaching, neutralization, and chemical oxidation. All of these treatment technologies are to be followed by stabilization.

The alternative LDR treatment standard for debris is treatment prior to land disposal using any of the following technologies: extraction (physical, chemical, or thermal), destruction (biological, chemical, or thermal), macro/microencapsulation or sealing.

The waste is a mixture of a variety of different materials of different sizes and shapes. Contamination is assumed to have penetrated into the matrices of the combustible (including wood) wastes. Several of the volatile or unstable organics identified, such as methyl isobutyl ketone and hydrazine, may have volatilized or decomposed and may no longer be part of this waste stream.

It is assumed that the mercury referred by the EPA Code D009 refers to the contaminated combustible waste only, and that liquid mercury is not included in this waste stream.

Treatability Group

Radiological Constituents:
This waste is classified as contact-handled with 10-100 nCi/g of alpha contamination.

Contaminants:
This waste is contaminated with heavy metals, including beryllium and mercury, and organics. The following EPA regulated wastes are suspected to be contained within the waste stream.

D001: Unlisted hazardous waste characteristic of ignitability
D003: Unlisted hazardous waste characteristic of reactivity
D004: Arsenic
D006: Cadmium
D007: Chromium
D008: Lead
D009: Mercury
D011: Silver
D019: Carbon tetrachloride
D022: Chloroform
D023: Ortho-cresol
D024: Meta-cresol
D025: Para-cresol
D026: Cresol
P012: Arsenic oxide
P015: Beryllium
P048: 2,4-Dinitrophenol
P113: Thallium oxide
P120: Vanadium oxide
U002: 2-Propanone
U032: Chromic acid, H2Cro4 calcium salt
U052: Cresylic acid
U080: Methylene chloride
U133: Hydrazine
U134: Hydrogen fluoride
U144: Lead acetate
U151: Mercury
U154: Methyl alcohol
U161: Methyl isobutyl ketone
U209: 1,1,1, Tetrachloroethane
U211: Carbon tetrachloride
U220: Toluene
U226: 1,1,1, Trichloroethane
U239: Xylene mixed

Matrix:
This waste consists of heterogeneous debris.

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Heterogeneous Debris / 5400 **Site:** Savannah River

Alternative/Technology

CHEMICAL TREATMENT

Chemical Deactivation; Decontamination via CO2 Blasting; Chemical Oxidation; Chemical Reduction.

(Note: Although only a few chemical oxidation reagents have been identified here, various reagents that could be utilized to perform chemical oxidation include ozone, permanganate, hydrogen peroxide, hypochlorite, and sulfur dioxide. Various oxidation techniques utilized could include wet air oxidation, electrolytic oxidation, or ozonation via an ultraviolet light.)

Chemical deactivation is applicable to all portions of this waste stream. Other chemical treatment technologies are applicable only to the large metals portion of this waste stream.

Chemical deactivation to eliminate the reactivity of the waste will be performed via a controlled reaction, utilizing water as the reagent. The process should be conducted in an atmosphere that will mitigate occurrences of gas generation and/or explosions. Deactivated wastes will be sorted into categories of combustibles and metals.

Combustibles and small metal pieces will be treated via incineration (see thermal treatment or physical treatment).

Large Metals will be treated via decontamination, chemical oxidation, chemical reduction, and dehydration/evaporation. Chemical immobilization of contaminants adhering to the surfaces of waste metals can be accomplished via CO2 Blasting. CO2 Blasting is the removal of contamination via a pressurized spray of frozen carbon dioxide pellets. The frozen CO2 evaporates and the contaminants will be swept up off of the floor and treated via a caustic (hydrogen peroxide or permanganate) chemical oxidation process.

After the destruction of the organics, the solution can be lowered to a pH of 4-5, and ferrous sulfate added to precipitate the metal contaminants. The slurry is then dehydrated/evaporated down to a sludge to enable the physical treatment of the heavy metal contaminants via stabilization.

Status

Chemical deactivation; decontamination via CO2 Blasting; chemical oxidation; chemical reduction; and dehydration/evaporation technologies have been previously used in industry on similar waste types.

Subsystems required
- Deactivation area/equipment
- Manual sorting system
- CO2 blasting system
- Chemical oxidation system
- Acid addition system
- Chemical reduction system
- Dehydration/evaporation system

Projected performance
- Expected to produce a product that can be stabilized into a final waste form for disposal

Science and Technology Needs

Demonstration of this technology with respect to the treatment of these specific contaminants within this specific waste matrix is needed.

Implementation Analysis

Many subsystems make the treatment of this waste stream labor intensive. A pressurized spray within the presence of alpha contamination may cause safety concerns.

Input waste stream characterization information needed

Waste stream

Concentration of organic contaminants (see organic contaminants in the characterization subelement beginning on page L-15).

Oxidation process solution

An accurate COD analysis of the waste is required to determine the reagents necessary to promote oxidation of the organics within the waste (see Chemical-Oxygen Demand analysis in the characterization subelement beginning on page L-15).

Concentration of metal salts. Metal salts, especially silver salts, will react with the oxidizing agents to form metal oxides which can interfere with the effectiveness of the treatment process (see concentration of metal salts in the characterization subelement beginning on page L-15).

pH of the waste (see pH in the characterization subelement beginning on page L-15).

The presence and concentration of organics within the waste will be necessary to select the appropriate chemical oxidation treatment method (see organic contaminants in the characterization subelement beginning on page L-15).

Waste streams produced

Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1).

Sludge that requires stabilization (see sludge under secondary waste streams beginning on page L-10).

Decontaminated metal debris can be disposed of as a LLW (see metal debris disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Heterogeneous Debris / 5400 **Site:** Savannah River

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
The required concentrations of the reagents will be based on the Chemical-Oxygen Demand (COD) analysis of the solution. Temperature control and Oxidation-Reduction Potential (ORP) monitoring are standard control technologies utilized for COD analysis. The process can be monitored via the COD analysis to determine when the organics are completely destroyed. For accurate COD analysis, the hydrogen peroxide (if utilized as the oxidizer) must be neutralized prior to the performance of the analysis.			
→ Chemical Deactivation; Decontamination via Polyethylene-Bead Blasting; Chemical Oxidation; Chemical Reduction. (Note: Although only a few chemical oxidation reagents have been identified here, various reagents that could be utilized to perform chemical oxidation include ozone, permanganate, hydrogen peroxide, hypochlorite, and sulfur dioxide. Various oxidation techniques utilized could include wet air oxidation, electrolytic oxidation, or ozonation via an ultraviolet light.) Chemical deactivation is applicable to all portions of this waste stream. Other chemical treatment technologies are applicable only to the large metals portion of this waste stream. Chemical deactivation to eliminate the reactivity of the waste will be performed via a controlled reaction, utilizing water as the reagent. The process should be conducted in an atmosphere that will mitigate occurrences of gas generation and/or explosions. Deactivated wastes will be sorted into categories of combustibles and metals. Combustibles and small metal pieces will be treated via incineration (see thermal treatment or physical treatment). Large Metals will be treated via decontamination, chemical oxidation, chemical reduction, and dehydration/evaporation. Chemical immobilization of contaminants adhering to the surfaces of waste metals can be accomplished via Polyethylene-	→ Chemical deactivation; decontamination via polyethylene-bead blasting; chemical oxidation; chemical reduction; and dehydration/evaporation technologies have been previously used in industry on similar waste types. Subsystems required Deactivation area/equipment Manual sorting system Polyethylene-Bead blasting system Chemical oxidation system Acid addition system Chemical reduction system Dehydration/evaporation system Projected performance Expected to produce a product that can be stabilized into a final waste form for disposal	→ Demonstration of this technology with respect to the treatment of these specific contaminants within this specific waste matrix is needed.	→ Many subsystems make the treatment of this waste stream labor intensive. A pressurized spray within the presence of alpha contamination may cause safety concerns. <u>Input waste stream characterization information needed</u> <u>Waste stream</u> Concentration of organic contaminants (see organic contaminants in the characterization subelement beginning on page L-15). <u>Oxidation process solution</u> An accurate COD analysis of the waste is required to determine the reagents necessary to promote oxidation of the organics within the waste (see Chemical-Oxygen Demand analysis in the characterization subelement beginning on page L-15). Concentration of metal salts. Metal salts, especially silver salts, will react with the oxidizing agents to form metal oxides which can interfere with the effectiveness of the treatment process (see concentration of metal salts in the characterization subelement beginning on page L-15). pH of the waste (see pH in the characterization subelement beginning on page L-15). The presence and concentration of organic within the waste will be necessary to select the appropriate chemical oxidation treatment method (see organic contaminants in the characterization subelement beginning on page L-15).

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Heterogeneous Debris / 5400 **Site:** Savannah River

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Bead Blasting. Polyethylene-Bead Blasting is the removal of contamination via a pressurized spray of polyethylene beads. The contaminants adhere to the beads or will drop onto the floor. The contaminants and beads will be swept up off of the floor and treated via a caustic (hydrogen peroxide or permanganate) chemical oxidation process. After the destruction of the organics, the solution can be lowered to a pH of 4-5, and ferrous sulfate added to precipitate the metal contaminants. The slurry is then dehydrated/evaporated down to a sludge to enable the physical treatment of the heavy metal contaminants via stabilization. The required concentrations of the reagents will be based on the Chemical-Oxygen Demand (COD) analysis of the solution. Temperature control and Oxidation-Reduction Potential (ORP) monitoring are standard control technologies utilized for COD analysis. The process can be monitored via the COD analysis to determine when the organics are completely destroyed. For accurate COD analysis, the hydrogen peroxide (if utilized as the oxidizer) must be neutralized prior to the performance of the analysis. → THERMAL TREATMENT → ALTERNATIVE - Incineration			Waste streams produced Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1). Sludge that requires stabilization (see sludge under secondary waste streams beginning on page L-10). Decontaminated metal debris can be disposed of as a LLW (see metal debris disposal beginning on page N-1).
→ Controlled Air Incineration (CAI) stationary hearth incinerator usually designed with a two-or three-stage combustion process. Solid wastes are fed into a primary chamber to be burned using sub-stoichlometric air, thus destroying the volatile constituents. A high-temperature secondary combustion chamber is operated with excess air to assure complete destruction of volatile organic materials. Liquid waste materials are burned either in the primary or secondary chambers (dependent on the waste's characteristics). High-temperature volatilities of certain metals (such as arsenic, mercury, selenium, cadmium, and lead) require the subsequent capture in the incinerator offgas. The incinerator offgases would be subsequently cooled in order to allow these metals (or compounds) to condense prior to being entrained via a particulate removal device.	→ Accepted by industry. The DOE has operated controlled air incinerators in TRU and LLW service. Process may generate TRU wastes, therefore handling systems will need to be designed for such materials Subsystems required Feed preparation shredder for sizing solids (as applicable) Feed examination system to remove glass and other melting materials Large offgas treatment system, including acid gas scrubber, and particulate filters Ash handling system Metals treatment system (such as amalgamation, chemical reduction) Stabilization system for treatment residuals	→ Better characterization of the waste stream to determine the extent of volatilization of metallic waste constituents. Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems.	→ Normal implementation needs. Captured metals and treatment residue will require treatment/stabilization prior to disposal. Controlled air incineration technology is commercially available and is currently planned in the DOE system for usage on this waste type. The required subsystems are commercially available. The large number of subsystems required make this technology relatively complicated and labor intensive, however the modular design of the incinerator and use of a wide variety of secondary fuels lower operational costs. Input waste stream characterization information needed Characterization requirements may include the identification of volatile metals in the waste stream. (see volatile metals in the characterization subelement beginning on page L-15).

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Heterogeneous Debris / 5400 **Site:** Savannah River

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Incineration (continued)	Projected performance Good organic destruction Reaction of waste materials with refractory materials may be a problem dependent on the waste stream feed characteristics, of most concern is the hydrofluoric acid due to it's corrosive nature with ceramic materials is corrosive with common refractories Post-treatment stabilization of ash residuals using cement is currently in wide use; long-term leaching performance is suspect; volume reduction is moderate; alternate stabilization techniques possible for better long-term performance		Corrosive tendency of waste materials (The acid and salt content will be used to correlate the corrosivity of the waste material. See pH in the characterization subelement beginning on page M-12 and salt content in the characterization subelement beginning on page B-11). Waste streams produced Bottom ash that requires stabilization (see bottom ash under secondary waste streams beginning on page L-10). Flyash that requires stabilization (see flyash under secondary waste streams beginning on page L-10). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page L-10). Offgas particulate filters that requires shredding followed by stabilization (see offgas particulate filters under secondary waste streams beginning on page L-10). Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1). Mercury offgas (see mercury offgas under secondary waste streams beginning on page L-13).
Rotary Kiln Cylindrical refractory-lined shell mounted on a slight incline; rotation of the kiln moves the noncontainerized waste through the shell, enhancing mixing. A secondary combustion chamber commonly follows the primary chamber. High-temperature volatilities of certain metals (such as arsenic, mercury, selenium, cadmium, and lead) require their subsequent capture in the incinerator offgas. The incinerator offgases would be subsequently cooled in order to allow these metals (or compounds) to condense prior to being entrained in a particulate. Rotary kilns cannot operate in a cyclic (on-off) mode.	Accepted by industry. The EPA has approved this technology as the BDAT for organics, as well as cyanide. The DOE is operating a rotary kiln for waste incineration, and planning other operations of this type. Subsystems required Shredding/sorting Large offgas treatment system, including acid-gas scrubber, metal removal (capture) system, and particulate filters Ash handling system Mercury treatment system (such as amalgamation for mercury) Stabilization system for treatment residuals Projected performance Good organic destruction Rotating kiln seals questionable for contamination control (i.e., reaction of waste materials with refractory materials must be addressed and, excursions	Better characterization of the waste stream is necessary to determine the extent of possible volatilization of other waste consituents. Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems. Immobilization agent will have to be selected and demonstrated.	Normal implementation needs. Captured metals and treatment residue will require treatment/stabilization prior to disposal. The rotary kiln incineration technology is commercially available and currently used within the commercial sector. The technology is currently in use within the DOE sector for non-cemented sludge wastes. The required subsystems, as described above, are commercially available. The moving parts and large number of subsystems required make this technology relatively complicated and labor intensive. Input waste stream characterization information needed Characterization requirements may include the identification of volatile metals in this waste stream (see volatile metals in the characterization subelement beginning on page L-15). Corrosive tendency of waste materials on refractory materials (The acid and salt content will be used to correlate the corrosivity of the waste material. See

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Heterogeneous Debris / 5400 **Site:** Savannah River

Alternative/Technology

Rotary Kiln (continued)

Status

within the kiln may produce fugitive emissions via the kiln seals)
Post-treatment stabilization of ash residuals using cement is currently in wide use; volume reduction is moderate; alternate stabilization techniques possible for better long-term performance

Science and Technology Needs

Implementation Analysis

pH in the characterization subelement beginning on page M-12 and salt content in the characterization subelement beginning on page B-11).

Waste streams produced

Bottom ash that requires stabilization (see bottom ash under secondary waste streams beginning on page L-10).

Flyash that requires stabilization (see flyash under secondary waste streams beginning on page L-10).

Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page L-10).

Offgas particulate filters that require shredding followed by stabilization (see offgas particulate filters under secondary waste streams beginning on page L-10).

Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1).

Mercury offgas (see mercury offgas under secondary waste streams beginning on page L-13).

Alternative/Technology

ALTERNATIVE - Thermal Desorption

Retorting/roasting

Low-temperature thermal unit in which volatile materials, such as mercury, are volatilized for subsequent capture of the metal in the offgas. Volatilization of the other waste constituents is lower than in an incinerator due to lower process temperatures. The roaster offgases would be cooled to condense out mercury and mercury compounds to low levels prior to being entrained via a particulate removal device.

Status

Accepted by industry. The EPA has approved this technology as the BDAT for nonwastewaters containing high levels of mercury.

Subsystems required

- Feed pretreatment shredder for sizing (as applicable)
- Small offgas treatment system, including acid gas scrubber, metals scrubber, and particulate filters
- Secondary combustion system to ensure destruction of organics (or adsorbents)
- Carbon adsorption system to capture mercury in the offgas
- Ash handling system
- Metals treatment system for treatment of scrubber (such as amalgamation, blowdown or chemical reduction)
- Stabilization system for treatment residuals

Projected performance

- Good organic destruction in secondary combustor
- Post-treatment stabilization of ash residues using cement is currently in wide use

Science and Technology Needs

Better characterization of waste stream to determine extent of possible volatilization of waste constituents and to determine whether the waste requires mixing during treatment (to enable all of the contaminated materials to be exposed to the unit's processing temperatures). Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems.

Implementation Analysis

Normal implementation needs. Captured metals and treatment residue will require treatment/stabilization prior to disposal. This technology and its subsystems are commercially available and are currently in use in the commercial sector. Although it has few moving parts, the large number of subsystems required make this technology relatively complicated and labor intensive.

Input waste stream characterization information needed

Characterization requirements may include the identification of volatile metals in this waste stream (see volatile metals in the characterization subelement beginning on page L-15).

Heat of combustion.

Corrosive tendency of waste materials (The acid and salt content will be used to correlate the corrosivity of the waste material. See pH in the characterization subelement beginning on page M-12 and salt content in the characterization subelement beginning on page B-11).

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Heterogeneous Debris / 5400 **Site:** Savannah River

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Retorting/roasting (continued)	Long-term leaching performance is suspect Volume reduction is moderate		Waste streams produced Bottom ash that requires stabilization (see bottom ash under secondary waste streams beginning on page L-10). Flyash that requires stabilization (see flyash under secondary waste streams beginning on page L-10). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page L-10). Offgas particulate filters that require shredding followed by stabilization (see offgas particulate filters under secondary waste streams beginning on page L-10). Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1). Mercury offgas (see mercury offgas under secondary waste streams beginning on page L-13).
Physical treatment via stabilization is applicable to waste streams classified as debris per the EPA debris rule			
ALTERNATIVE - Solidification/Stabilization (combustible and small metal debris)			
Sulfur Polymer Cement (SPC) Sulfur Polymer Cement is composed of 95% sulfur. It melts at approximately 110 to 120°C and is particularly valuable in the immobilization of combustibles and small metal pieces.	SPC is being developed by the DOE for usage with this type of waste stream at INEL. SPC has been demonstrated on ash. SPC is not compatible with waste streams containing high nitrates. Subsystems required Waste feed system Ingredients feed system Shredder for combustibles and small metal pieces Projected performance Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input waste stream characterization information needed The concentration of sodium, potassium, sulfates, nitrates, and chlorides (see concentration of soluble salt in the characterization subelement beginning on page M-12). Waste streams produced A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW) (see solidified waste forms disposal beginning on page N-1).
Chemically-bonded Ceramics (CbC) Chemically-bonded ceramic waste forms are produced by mixing the wastes and inorganic oxide binders together. The mixture is then processed at ambient and near ambient temperatures, promoting chemical reactions that bond the waste and the inorganic oxides into a dense ceramic material.	CbC is in early stages for development by the DOE for usage on this type of waste streams. Subsystems required Waste feed system Ingredients feed system Shredder for combustibles and small metal pieces Projected performance Expected to produce a suitable final waste form for	Technology must be demonstrated on this waste stream.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input waste stream characterization information needed The concentration of sodium, potassium, sulfates, nitrates, and chlorides (see concentration of soluble salt in the characterization subelement beginning on page M-12).

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Heterogeneous Debris / 5400 **Site:** Savannah River

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Chemically-bonded Ceramics (CbC) (continued)	disposal		Waste streams produced A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919

Matrix: Heterogeneous Debris / 5400

Subelement: Treatment

Site: Savannah River

Secondary Waste Stream

Bottom ash
Carbon filters
Flyash
Mercury salts
Offgas particulate filters
Scrubber residue
Sludge

Treatability Group

Radiological Constituents:
This waste may be classified as a waste containing 10-100 nCi/g of alpha-emitting radionuclides. However the waste may be classified as TRU waste, if the radionuclides in the waste feed become concentrated within the products generated by the treatment process.

Contaminants:
This waste is contaminated with toxic metals, including arsenic, beryllium, cadmium, chromium. lead, mercury, and silver. The following EPA-regulated wastes are suspected to be contained within the waste stream.

P012: Arsenic oxide
P015: Beryllium
P048: 2,4-Dinitrophenol
P113: Thallium oxide
P120: Vanadium oxide
U002: 2-Propanone
U032: Chromic acid, H2Cro4 calcium salt
U052: Cresylic acid
U080: Methylene chloride
U133: Hydrazine
U134: Hydrogen fluoride
U144: Lead acetate
U151: Mercury
U154: Methyl alcohol
U161: Methyl isobutyl ketone
U209: 1,1,1, Tetrachloroethane
U211: Carbon tetrachloride
U220: Toluene
U226: 1,1,1, Trichloroethane
U239: Xylene mixed

Matrix:
This waste consists of ash, sludge, scrubber residue, filters, mercury salts.

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Heterogeneous Debris / 5400 **Site:** Savannah River

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
ALTERNATIVE - Solidification/Stabilization			
Polyethylene Polyethylene is an inert thermoplastic material that can be processed at low temperatures. Polyethylene binder and dry waste material are fed through separate calibrated volumetric or loss-in-weight feeders to an extruder. The materials are then thoroughly mixed, heated to a molten condition, and extruded into a suitable mold. On cooling, the mixture forms a solid monolithic waste form. No chemical reaction is required for solidification.	Polyethylene is being developed by the DOE for usage on these types of waste streams. Polyethylene has been demonstrated on scrubber residues. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and the compatibility of the process with the actual constituents contained in the waste stream. The technology needs development on the treatment of shredded particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input waste stream characterization information needed The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). Waste streams produced A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see solidified waste forms disposal beginning on page N-1).
Sulfur Polymer Cement (SPC) Sulfur Polymer Cement is composed of 95% sulfur. It melts at approximately 110 to 120°C and is particularly applicable to the immobilization of toxic metals and treatment of incinerator ash.	SPC is being developed by the DOE for usage within these types of waste streams. SPC has been demonstrated on ash. SPC is not compatible with waste streams containing high nitrates. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and the processes' compatibility with the actual waste stream's constituents. The technology needs development on the treatment of shredded particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. Input waste stream characterization information needed The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). Waste streams produced A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Heterogeneous Debris / 5400 **Site:** Savannah River

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Chemically-bonded Ceramics (CbC) → Chemically-bonded ceramic waste forms are produced by mixing the wastes and inorganic oxide binders together. The mixture is then processed at ambient and near ambient temperatures, promoting chemical reactions that bond the waste and the inorganic oxides into a dense ceramic material.	CbC is in early stages for development by the DOE for usage on these types of waste streams. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and the processes' compatibility with the actual waste stream's constituents. The technology needs development on the treatment of shredded particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Heterogeneous Debris / 5400 **Site:** Savannah River

Secondary Waste Stream
Mercury offgas

Treatability Group

Radiological Constituents:
This waste may be classified as waste containing 10-100 nCi/g of alpha-emitting radionuclides. However the waste may be classified as TRU waste, if the radionuclides in the waste feed become concentrated within the products generated by the treatment process.

Contaminants:
This waste is contaminated with toxic metals, including arsenic, beryllium, cadmium, chromium. lead, mercury, and silver. The following EPA regulated wastes are suspected to be contained within the waste stream.

P012: Arsenic oxide
P015: Beryllium
P048: 2,4-Dinitrophenol
P113: Thallium oxide
P120: Vanadium oxide
U002: 2-Propanone
U032: Chromic acid, H2Cro4 calcium salt
U052: Cresylic acid
U080: Methylene chloride
U133: Hydrazine
U134: Hydrogen fluoride
U144: Lead acetate
U151: Mercury
U154: Methyl alcohol
U161: Methyl isobutyl ketone
U209: 1,1,1, Tetrachloroethane
U211: Carbon tetrachloride
U220: Toluene
U226: 1,1,1, Trichloroethane
U239: Xylene mixed

Matrix:
This waste consists of an offgas stream.

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919 **Subelement:** Treatment

Matrix: Heterogeneous Debris / 5400 **Site:** Savannah River

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
ALTERNATIVE Mercury Offgas Removal and Treatment			
Sodium Hypochlorite Injection; Cupric Chloride Injection; Carbon Adsorption The capture rate of mercury in the offgas utilizing only a wet scrubbing process may not be sufficient. If the concentration of the mercury in the waste is high, additional steps to remove mercury from the offgas may be necessary. Subjecting the offgas to a wet sodium hypochlorite or chelating agent/cupric chloride injection during the wet scrubbing process or subjecting the offgas to a carbon absorption following the wet scrubbing process will enable a greater capture rate of mercury. Mercury-contaminated carbon filters will have to be shredded and stabilized. Mercury-contaminated wet blowdown liquids will require chemical treatments such as chemical oxidation (to destroy the chelating agent if it is used), chemical reduction of toxic metals, and/or amalgamation of mercury (depending on the concentration of mercury and other metals contained within the blowdown). The slurry will then be dehydrated down to a sludge and treated via stabilization.	Accepted by industry. Subsystems required Feed pretreatment in treatment of volatile mercury System for mercury removal from carbon if encapsulation of charcoal with mercury is not acceptable for disposal Mercury treatment system such as amalgamation or chemical oxidation Projected performance High mercury removal efficiency at low cost Effective at removing trace quantities of other contaminants Simple to operate and maintain Potential problem with self-ignition on contact with oxygen	The issue of secondary treatment of the carbon/mercury residual or separation of the mercury from the carbon for final treatment and disposal needs to be resolved.	There are commercially available sorbent systems that must be demonstrated or applied to this application. <u>Input waste stream characterization information needed:</u> Concentrations of mercury in the waste (see concentration and chemical form of mercury in the characterization subelement beginning on page L-15). <u>Waste streams produced</u> Charcoal that is contaminated with mercury requires stabilization (see carbon filters under secondary waste streams beginning on page L-10).
Sodium Sulfide Injection Sodium sulfide is a crystalline solid that dissolves in water and is sprayed into the flue gas prior to acid gas removal. Lower concentrations, approximately 2% to 4% have been found to give better performance than higher concentrations. When used with municipal waste incineration, approximately 0.1 to 1 lb. of sodium sulfide is required per ton of waste.	Demonstration. New technology employed by a few operational facilities Subsystems required Feed pretreatment in treatment of volatile mercury System for residual treatment Projected performance Medium to high mercury removal Simple to operate Potential handling and deposition problems with sodium sulfide	Improvements needed in the atomization process to improve mass transfer effectiveness. Demonstration of this technology with respect to the treatment of this specific waste stream is needed. A treatment must also be developed to enable proper disposal of the resulting residue.	Normal implementation needs. The technology is simple, but control and handling of the sodium sulfide requires care to prevent emission of sulfide fumes. <u>Input waste stream characterization information needed</u> Concentrations levels of mercury in the waste (see concentration and chemical form of mercury in the characterization subelement beginning on page L-15). <u>Waste streams produced</u> Mercury salts contaminated with radionuclides require stabilization (see mercury salts under secondary waste streams beginning on page L-10).

Mixed Waste Integrated Program

Logic Diagram

Savannah River
SRS Thirds Waste
Characterization Technologies

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919 **Subelement:** Characterization

Matrix: Heterogeneous Debris / 5400 **Site:** Savannah River

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Organic contaminants.	Gas Chromatography/Mass Spectrometry (GC/MS)	Accepted by EPA. Gas chromatography-mass spectrometry (GC-MS) is a technique which provides separation of volatile and semi-volatile organic molecules by gas chromatography and detection by mass spectrometry. Utilizes the separation characteristics of various chromatographic columns; qualitative and quantitative data are obtained by correlating masses detected with the elution times.	None. Technology is applicable as is. Benefit would be derived from faster chromatography to shorten analysis time.	Method(s)/Instrument(s) available. Mature technology.
Chemical Oxygen Demand (COD) analysis.	Chemical Oxygen Demand (COD) determines the quantity of oxygen required to oxidize the organic matter in a waste sample, under specific conditions of oxidizing agent, temperature and time. There is no technology to determine COD.	EPA has developed laboratory procedures to determine COD of waste material. These procedures are: EPA Method 410.1 (Titrimetric, Mid-Level) EPA Method 410.2 (Titrimetric, Low-Level) EPA Method 410.3 (Titrimetric, High-Level for Saline Waters) EPA Method 410.4 (Colorimetric, Automated; Manual)	None.	Method(s)/Instrument(s) available.
Concentration of metal salts (especially silver salts).	Atomic Absorption (AA), Furnace Technique	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following method to determine the concentration of silver in wastes: EPA Method 272.2 - silver (detection limit 0.2 ug/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Simultaneous background corrections must be made for all metals to avoid erroneously high results.
	Atomic Absorption (AA), Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following method for determining the concentration of silver metal in wastes: EPA Method 273.1 - silver (detection limit 0.002 mg/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required.

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919 **Subelement:** Characterization
Matrix: Heterogeneous Debris / 5400 **Site:** Savannah River

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES' primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. This can be reduced by diluting the sample using a peristolic pump, or by using the standard additions method. Estimated detection limit for silver metal: EPA Method 200.7 - silver (detection limit 0.002 mg/L)	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).
	Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8). Estimated instrument detection limits for silver metal: EPA Method 200.8 - silver (detection limit 0.05 ug/L	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s)/Instrument(s) available.

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919 **Subelement:** Characterization

Matrix: Heterogeneous Debris / 5400 **Site:** Savannah River

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Ion Chromatography (IC)	Accepted by EPA and industry. Ion Chromatography (EPA Method 300.0) is able to quickly and accurately determine anions in solution to ppm or ppb concentrations. In order to use IC for solids, an extraction method outlined in EPA Method 300.0 must be performed. Additional separation techniques may be needed to further separate ionic species. EPA Method 300.0 - fluoride (detection limit 0.01 mg/L) EPA Method 300.0 - chloride (detection limit 0.02 mg/L) EPA Method 300.0 - nitrate (detection limit 0.002-0.004 mg/L) EPA Method 300.0 - sulfate (detection limit 0.02 mg/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available.
pH	Electrometric	Accepted and proven technology. This method (EPA Method 150.1) is applicable to aqueous wastes and is determined electrometrically using either a glass electrode in combination with a reference potential or a combination electrode. The pH can also be continuously monitored per EPA Method 150.2.	None.	Method(s)/Instrument(s) available. Off-the-shelf technology.
Volatile metals (such as arsenic, mercury, cadmium, selenium, and lead).	Atomic Absorption (AA), Furnace Technique	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.0). EPA has approved the following methods for determining the concentration of volatile metals in wastes: EPA Method 206.2 - arsenic (detection limit 1 ug/L) EPA Method 213.2 - cadmium (detection limit 0.1 ug/L) EPA Method 270.2 - selenium (detection limit 2 ug/L) EPA Method 239.2 - lead (detection limit 1 ug/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available. are must be taken to minimize the loss of volatile metals during sample preparation. Arsenic and selenium analysis can suffer from severe nonspecific absorption and light scattering by matrix components during atomization due to their low analytical wavelengths. Simultaneous background corrections must be made for all metals to avoid erroneously high results.

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919 **Subelement:** Characterization

Matrix: Heterogeneous Debris / 5400 **Site:** Savannah River

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Atomic Absorption (AA), Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.0). EPA has approved the following methods for determining the concentration of volatile metals in wastes: EPA Method 213.1 - cadmium (detection limit 0.005 mg/L) EPA Method 239.1 - lead (detection limit 0.1 mg/L)	None, with proper sample preparation.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required. For concentrations of cadmium below 0.02 mg/L, the furnace procedure (EPA Method 213.2) is recommended. For concentrations of lead below 0.2 mg/L, the furnace procedure (EPA Method 239.2) is recommended.
	Atomic Absorption, Cold-Vapor	Accepted. Samples must be converted to suitable solutions for analysis. EPA has approved the following methods for determining the total mercury (inorganic and organic) in solid wastes: EPA Method 245.5 - mercury (detection limit .0002 mg/L)	None. All samples must be subject to an appropriate dissolution step prior to analysis.	Method(s)/Instrument(s) available. Potassium permanganate is added to eliminate possible interference from sulfide. Wastes high in chloride require additional permanganate. Certain volatile organic absorb at the wavelength of mercury vapor (253.7-nm). A preliminary run without reagents should determine if this type of interference is present.
	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919 **Subelement:** Characterization

Matrix: Heterogeneous Debris / 5400 **Site:** Savannah River

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (continued)	reduced by diluting the sample, delivering a consistent flow of sample to the instrument via the use of a peristaltic pump, and/or by the use of the standard additions method. EPA Method 200.7 - arsenic (detection limit 0.008 mg/L) EPA Method 200.7 - mercury (detection limit 0.02 mg/L) EPA Method 200.7 - cadmium (detection limit 0.001 mg/L) EPA Method 200.7 - selenium (detection limit 0.02 mg/L) EPA Method 200.7 - lead (detection limit 0.01 mg/L)		
	→ Inductively-Coupled Plasma Mass Spectrometry (ICP-MS) →	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8). EPA Method 200.8 - arsenic (detection limit 0.9 ug/L) EPA Method 200.8 - cadmium (detection limit 0.1 ug/L) EPA Method 200.8 - selenium (detection limit 5 ug/L) EPA Method 200.8 - lead (detection limit 0.08 ug/L) →	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation. →	Method(s)/Instrument(s) available.
Concentration and chemical form of mercury. →	Atomic Absorption, Cold-Vapor →	Accepted. Samples must be converted to suitable solutions for analysis. EPA has approved the following methods for determining the total mercury (inorganic and organic) in solid wastes: EPA Method 245.5 - mercury (detection limit .0002 mg/L) →	None. All samples must be subject to an appropriate dissolution step prior to analysis. →	Method(s)/Instrument(s) available. Potassium permanganate is added to eliminate possible interference from sulfide. Wastes high in chloride require additional permanganate. Certain volatile organic absorb at the wavelength of mercury vapor (253.7-nm). A preliminary run without reagents should determine if this type of interference is present.

Mixed Waste Integrated Program Logic Diagram

Name: SRS Thirds Waste **MWIR#:** 919 **Subelement:** Characterization
Matrix: Heterogeneous Debris / 5400 **Site:** Savannah River

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	→ Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES) →	Accepted. ICP-AES' primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis. The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. These inaccuracies can be reduced by diluting the sample, delivering a consistent flow of sample to the instrument via the use of a peristolic pump, and/or by the use of the standard additions method. EPA Method 200.7 - mercury (detection limit: 0.02 mg/L) →	None, with proper sample preparation. This is a well-developed technology. →	Method(s)/Instrument(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).

Mixed Waste Integrated Program

Logic Diagram

West Valley
Pyridine/Cyanide Waste
Treatment Technologies

Mixed Waste Integrated Program Logic Diagram

Name: Pyridine/Cyanide Waste **MWIR#:** 1051 **Subelement:** Treatment

Matrix: Uncatagorized Aqueous-Organic Liquids / 2190 **Site:** West Valley

Waste Stream

Waste Stream Desctiption

This waste stream consists of toxic heavy metals like chromium and has acidic corrosivity and toxicity characteristics.

Problems Presented by Waste Stream

LDR treatment standards for this waste stream are deactivation and chemical reduction followed by stablization. However, the LDR treatment standards do not address the Pyridine contained within the waste (i.e., no destruction of organics is involved in the deactivation or chemical reduction treatment processes).

The waste was generated through laboratory analysis of cyanide. The waste stream was previously named "Pyridine/Cyanide standards." The waste profile indicates that this waste is an acidic-aqueous waste contaminated with toxic metals and organics.

However, an aqueous solution with a pH of less than 2 (identified by the "acidic" description listed on the waste's profile report and the definition of an acidic waste carrying the EPA code D002) should contain no cyanide. This is due to the reaction between the cyanide and hydrogen atoms that form hydrogen-cyanide gases, which would be released into the atmosphere.

It is reasonable to conclude that a mistake may have been made with the listing of "acidic" on the waste profile sheet. Historically, cyanide analysis are carried out under basic conditions to prevent the formation of hydrogen-cyanide gases.

Both scenarios of waste acidity and basicity will be evaluated separately, enabling the identification of appropriate treatment methods for each scenario. Prior to treatment, waste characterization requirements will include the verification of the waste's pH, to enable the selection of the appropriate waste treatment technology.

This waste consists of approximately 0.023 M3 (6 gallons) of waste and therefore, may possibly be handled in a laboratory setting.

Treatability Group

Radiological Constituents:
This waste is classified as a Beta-Gamma emitter and as a contact-handled waste possessing < 10 nCi/g of alpha-emitting radionuclides.

Contaminants:
This waste stream is contaminated with toxic heavy metals such as chromium and has (acidic) corrosivity and toxicity characteristics. The following EPA regulated wastes are suspected to be contained within the waste stream.

D002: Unlisted hazardous waste characteristic of corrositivity
D007: Chromium
D011: Silver
D038: Pyridine

Matrix:
This waste consists of uncategorized aqueous organic liquid.

Mixed Waste Integrated Program Logic Diagram

Name: Pyridine/Cyanide Waste **MWIR#:** 1051 **Subelement:** Treatment

Matrix: Uncatagorized Aqueous-Organic Liquids / 2190 **Site:** West Valley

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
CHEMICAL TREATMENT Carbon Adsorption *Pyridine/Cyanide Waste Assumptions:* Acidic solution; Cyanide is depleted; Pyridine is $< 5\%$ by volume. Waste solution will be neutralized to a pH in the range of 5-7, via a caustic addition process. The neutralized waste solution will be cycled through granular activated carbon that has been packed in columns, allowing the pyridine to attach to the carbon. The required amount of carbon will be based on the organic contaminant's breakthrough point (the saturation point of the carbon). The amount of contaminants that can be actively adsorbed by activated carbon ranges from approximately 0.10 to 0.15 gram of organics per gram of carbon. The decrease of Total Organic Carbon (TOC) can be used to indicate a decrease in the concentrations of organics in the wastewater. TOC analysis can be used as a surrogate analysis if the analyte cannot be measured by other means.	Activated carbon is commonly used on wastewaters containing low levels of organic constituents. The EPA has approved biological treatment or wet-air oxidation, followed by carbon adsorption as the BDAT for wastewaters containing the organic constituent, pyridine. Has been used previously in industry to treat similar types of waste. Subsystems required Caustic addition system Activated carbon filtration system Projected performance Expected to produce a final waste form that can potentially be stabilized	Need to demonstrate that activated carbon containing ~5-10% organics can be stabilized and successfully pass the TCLP.	If no stabilization technology for this media can be identified, or if the pyridine concentration adsorbed to the media is such that it will not pass the TCLP, a petition for regulatory determination from the EPA can be initiated. If granted, this would enable the organically-contaminated carbon media to be classified as a "debris" and therefore exclude this media from being subjected to chemical destruction requirements, prior to being disposed of in a landfill. If either of the situations indicated above is anticipated, a petition for a regulatory determination from the EPA should be sought prior to performing the treatment of the wastewater via carbon adsorption. <u>Input waste stream characterization information needed</u> Concentration of pyridine (see concentration of pyridine in the characterization subelement beginning on page A-12). pH of the waste (see pH of waste in the characterization subelement beginning on page A-12). The presence and concentration of suspended solids (concentrations >50 mg/l can interfere with the treatment process) (see presence and concentration of suspended solids in the characterization subelement beginning on page A-12). The presence and concentration of oil and grease (concentrations >10 mg/l can interfere with the treatment process) (see presence and concentration of oil and grease in the characterization subelement beginning on page A-12). <u>Waste streams produced</u> Pyridine sorbed onto activated carbon material that requires stabilization (see activated carbon material under secondary waste streams beginning on page A-9).
Chemical Oxidation/Reduction Pyridine/Cyanide Waste Assumptions: Acidic solution; Cyanide is depleted; Pyridine concentration is $> 5\%$ by volume. (Note: Although only a few chemical oxidation reagents have been identified here, various reagents that could be utilized	Deactivation/neutralization via caustics, chemical oxidation/reduction via hydrogen peroxide/ferrous sulfate, and dehydration/evaporation are standard chemical treatment technologies that have been used previously in industry to treat similar types of waste.	Demonstration of this technology with respect to the treatment of these specific contaminants within this specific waste matrix is needed.	Multiple treatment systems make this treatment process labor intensive. Acid in the presence of an alpha-contaminated waste may present safety concerns. Because of the small amount of waste, this waste stream could be treated in the laboratory.

Mixed Waste Integrated Program Logic Diagram

Name: Pyridine/Cyanide Waste **MWIR#:** 1051 **Subelement:** Treatment

Matrix: Uncatagorized Aqueous-Organic Liquids / 2190 **Site:** West Valley

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Chemical Oxidation Reduction (continued) to perform chemical oxidation include ozone, permanganate, hydrogen peroxide, hypochlorite, and sulfur dioxide. Various oxidation techniques utilized could include wet air oxidation, electrolytic oxidation, or ozonation via an ultraviolet light). A caustic addition to deactivate/neutralize the waste will be performed. A hydrogen peroxide and ferrous sulfate oxidation/reduction process conducted at a pH of 4-5 will oxidize the organics and reduce any hexavalent chromium to trivalent chromium and any silver into an oxide form. This process will be followed by a caustic addition to produce a pH of 7-8, which will destroy any excess hydrogen peroxide. The remaining solution would be dehydrated to produce a metal (chromium, silver, and iron) hydroxide/oxide sludge. The required concentrations of the reagents will be based on the Chemical Oxygen Demand (COD) requirements of the waste. Temperature control and Oxidation-Reduction Potential (ORP) monitoring are the standard control technologies for this process. However, for this small volume the process can be monitored via COD analysis until it has been established that the organics are completely destroyed. In order to obtain an accurate COD analysis, the peroxide must be neutralized prior to the performance of the COD analysis.	Subsystems required Caustic neutralization system Chemical oxidation system Chemical reduction system Dehydration/evaporation system Projected performance Expected to produce a product that can be stabilized into a final waste form for disposal		<u>Input waste stream characterization information needed</u> An accurate COD analysis of the waste is required to determine the reagents necessary to promote oxidation of the organics within the waste (see Chemical Oxygen Demand analysis in the characterization subelement beginning on page M-12). Concentration of metal salts. Metal salts, especially silver salts, will react with the oxidizing agents to form metal oxides which can interfere with the effectiveness of the treatment process (see concentration of metal salts in the characterization subelement of this section). pH of the waste and the presence and concentration of cyanide within the waste will be necessary to select the appropriate oxidation treatment method (see pH of the waste and the presence and concentration of cyanide in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> Residual waste slurry/sludge that requires solidification (see slurry/sludge under secondary waste streams beginning on page M-9).
Chemical Oxidation/Chemical Reduction Pyridine/Cyanide Waste Assumptions: Basic solution; Cyanide is not depleted and is < 500 ppm. (Note: Although only a few chemical oxidation reagents have been identified here, various reagents that could be utilized to perform chemical oxidation include ozone, permanganate, hydrogen peroxide, hypochlorite, and sulfur dioxide. Various oxidation techniques utilized could include wet air oxidation, electrolytic oxidation, or ozonation via an ultraviolet light.) A chemical oxidation process (via hydrogen peroxide, hypochlorite, permanganate, or ozone) conducted at a solution pH in the range of 10-11.5 will	Deactivation/neutralization via caustics and acids; chemical oxidation/reduction via hydrogen peroxide, hypochlorite, permanganate, or ozone; chemical reduction via ferrous sulfate; and dehydration/evaporation are all standard chemical treatment technologies that have been used previously in industry to treat similar types of waste. Subsystems required Acidic neutralization system Chemical oxidation system Chemical reduction system Dehydration/evaporation system	Demonstration of this technology with respect to the treatment of these contaminants within this specific waste matrix is needed.	Multiple treatment systems make this treatment process labor intensive. Acid in the presence of an alpha-contaminated waste may present safety concerns. Because of the small amount of waste, this waste stream may possibly be treated in the laboratory. <u>Input waste stream characterization information needed</u> An accurate COD analysis of the waste is required to determine the reagents necessary to promote oxidation of the organics within the waste (see Chemical Oxygen Demand analysis in the characterization subelement beginning on page M-12). Concentration of metal salts. Metal salts, espe-

Mixed Waste Integrated Program Logic Diagram

Name: Pyridine/Cyanide Waste **MWIR#:** 1051 **Subelement:** Treatment

Matrix: Uncatagorized Aqueous-Organic Liquids / 2190 **Site:** West Valley

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Chemical Oxidation/Reduction (continued) oxidize and destroy the organics and convert cyanide to cyanate. The solution is then reduced via an acidic compound to a pH of 6-8, where the cyanate is converted to bicarbonate and oxygen. Hydrogen peroxide, if used as the oxidizer, will also be neutralized at the pH of 6-8. The solution is then lowered to a pH of 4-5, ferrous sulfate is added and the chromium and silver are reduced and converted to an oxide form. The remaining solution would be dehydrated to produce a metal (chromium, silver, and iron) hydroxide/oxide sludge. The required concentrations of the reagents will be based on the Chemical Oxygen Demand (COD) requirements of the waste. Temperature control and Oxidation-Reduction Potential (ORP) monitoring are the standard control technologies for this process. However, for this small volume the process can be monitored via COD analysis until it has been established that the organics are completely destroyed. In order to obtain an accurate COD analysis, the hydrogen peroxide (if utilized as the oxidizer) must be neutralized prior to the performance of the COD analysis.	Projected performance Expected to produce a product that can be stabilized into a final waste form for disposal		cially silver salts, will react with the oxidizing agents to form metal oxides which can interfere with the effectiveness of the treatment process (see concentration of metal salts in the characterization subelement beginning on page M-12). pH of the waste and the presence and concentration of cyanide within the waste will be necessary to select the appropriate oxidation treatment method (see pH of the waste and the presence and concentration of cyanide in the characterization subelement of this section). Waste streams produced Residual waste slurry/sludge that requires solidification (see slurry/sludge under secondary waste streams beginning on page M-9).
→ Electrolytic or Wet Air Oxidation; Chemical Reduction Pyridine/Cyanide Waste Assumptions: Basic solution; Cyanide is not depleted and is > 500 ppm. (Note: Although only a few chemical oxidation reagents have been identified here, various reagents that could be utilized to perform chemical oxidation include ozone, permanganate, hydrogen peroxide, hypochlorite, and sulfur dioxide. Various oxidation techniques utilized could include wet air oxidation, electrolytic oxidation, or ozonation via an ultraviolet light.) For wastes containing cyanide concentrations > 500 ppm, electrolytic or wet air oxidation will be used prior to chemical oxidation to reduce the CN- concentration < 500 ppm. The pH required for the electrolytic process is 11.5-12; the pH required for the wet air oxidation process is 10-11.5. Lime can be added to the waste during the electrolytic process (and the wet air oxidation process if nec-	→ Deactivation/neutralization via caustics and acids; chemical oxidation/reduction via hydrogen peroxide, hypochlorite, permanganate, or ozone; chemical reduction via ferrous sulfate; and dehydration/evaporation are all standard chemical treatment technologies that have been used previously in industry to treat similar types of waste. The EPA has approved biological treatment or wet-air oxidation, followed by carbon adsorption as the BDAT for wastewaters containing the organic constituent, pyridine. Subsystems required Electrolytic or a wet air oxidation system Caustic and/or acidic neutralization system Chemical oxidation system Chemical reduction system Dehydration/evaporation system Projected performance Expected to produce a product that can be stabilized into a final waste form for disposal	→ Demonstration of this technology with respect to the treatment of these specific contaminants within this specific waste matrix is needed.	→ Multiple treatment systems make this treatment process labor intensive. Acid in the presence of an alpha-contaminated waste may present safety concerns. Input waste stream characterization information needed An accurate COD analysis of the waste is required to determine the reagents necessary to promote oxidation of the organics within the waste (see Chemical Oxygen Demand analysis in the characterization subelement beginning on page M-12). Concentration of metal salts. Metal salts, especially silver salts, will react with the oxidizing agents to form metal oxides which can interfere with the effectiveness of the treatment process (see concentration of metal salts in the characterization subelement beginning on page M-12). pH of the waste and the presence and concentration of cyanide within the waste will be necessary to select the appropriate oxidation treatment method

Mixed Waste Integrated Program Logic Diagram

Name: Pyridine/Cyanide Waste **MWIR#:** 1051 **Subelement:** Treatment

Matrix: Uncatagorized Aqueous-Organic Liquids / 2190 **Site:** West Valley

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Electrolytic or Wet Air Oxidation (continued) essary) to keep the solution basic. Once the CN- is reduced to a concentration of < 500 ppm, chemical oxidation is a more effective means of eliminating the remaining CN-. A chemical oxidation process (via hydrogen peroxide, hypochlorite, permanganate, or ozone) conducted at a solution pH in the range of 10-11.5 will oxidize and destroy the organics and convert cyanide to cyanate. The solution is then reduced via an acidic compound to a pH of 6-8, where the cyanate is converted to bicarbonate and oxygen. Hydrogen peroxide, if used as the oxidizer, will also be neutralized at the pH of 6-8. The solution is then lowered to a pH of 4-5, ferrous sulfate is added and the chromium and silver are reduced and converted to an oxide form. The remaining solution would be dehydrated to produce a metal (chromium, silver, and iron) hydroxide/oxide sludge. The required concentrations of the reagents will be based on the Chemical Oxygen Demand (COD) requirements of the waste. Temperature control and Oxidation-Reduction Potential (ORP) monitoring are the standard control technologies for this process. However, for this small volume the process can be monitored via COD analysis until it has been established that the organics are completely destroyed. In order to obtain an accurate COD analysis, the hydrogen peroxide (if utilized as the oxidizer) must be neutralized prior to the performance of the COD analysis.			(see pH of the waste and the presence and concentration of cyanide in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> Residual waste slurry/sludge that requires solidification (see slurry/sludge under secondary waste streams beginning on page M-9).
→ THERMAL TREATMENT ALTERNATIVE - Vitrification			
→ Plasma Torch Direct Injection Refractory-lined chamber into which the liquid is directly injected into the plasma torch.	→ Bench scale testing of similar units completed. Subsystems required Waste feed system Offgas collection/treatment system, including off-gas scrubber and particulate filters Projected performance Highest temperature range, good organic destruc-	→ Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems.	→ Very high power requirements. This technology is far from commercial availability, but should be proven in 3-5 years. Unit operational costs are high but life cycle costs are low due to volume reduction effects on disposal costs. Minimal feed system requirements make this technology simple and non-labor intensive. Highest development risk of all of the thermal technologies.

Mixed Waste Integrated Program Logic Diagram

Name: Pyridine/Cyanide Waste **MWIR#:** 1051 **Subelement:** Treatment

Matrix: Uncatagorized Aqueous-Organic Liquids / 2190 **Site:** West Valley

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Plasma Torch (continued)	tion with no pretreatment Maximum volume reduction		Input waste stream characterization information needed No specific characterization requirements for this waste stream in this technology. Waste streams produced Slag may be disposed of as a RCRA LLW (but could also be classified as a RCRA alpha-contaminated LLW, or TRU waste) (see slag disposal beginning on page N-1). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page M-9). Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page M-9). Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1).
ALTERNATIVE - Incineration Controlled Air Incineration (CAI) A stationary hearth incinerator that is usually designed with a two or three stage combustion process. Solid wastes are fed into a primary chamber to be burned. Fifty to 80 percent of excess air is required to maintain stoichiometric conditions. The volatile constituents are destroyed. A high-temperature secondary combustion chamber is operated with excess air to assure complete destruction of volatile organic materials. Liquid waste materials are burned either in the primary or secondary chambers dependent on waste characteristics.	Accepted by industry. Subsystems required Feed preparation (if applicable) Large offgas treatment system, including offgas scrubber, metal removal system, and particulate filters Ash handling system Stabilization system for treatment residuals Projected performance Good organic destruction (including cyanides) Post-treatment stabilization of ash residuals using cement is currently widely used; long-term leaching performance is suspect; volume reduction is moderate; alternate stabilization techniques are available for better long-term stabilization	Technology must be demonstrated to assess its applicability to this waste stream, including the operation of the required subsystems.	Normal implementation needs. Controlled air incineration technology is commercially available and is currently planned to be utilized within the DOE system for this waste type. The required subsystems as described above are commercially available. The large number of subsystems required make this technology relatively complicated and labor intensive, however the modular design of the incinerator and use of a wide variety of secondary fuels lower operational costs. Input waste stream characterization information needed No specific characterization requirements for this waste stream in this technology. Waste streams produced Bottom ash that requires stabilization (see bottom ash under secondary waste streams beginning on page M-9). Flyash that requires stabilization (see flyash under secondary waste streams beginning on page M-9). Scrubber residue that requires stabilization (see scrubber residue under secondary waste streams beginning on page M-9).

Mixed Waste Integrated Program Logic Diagram

Name: Pyridine/Cyanide Waste **MWIR#:** 1051 **Subelement:** Treatment
Matrix: Uncatagorized Aqueous-Organic Liquids / 2190 **Site:** West Valley

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Controlled Air Incineration (continued)			Offgas particulate filters that require stabilization (see offgas particulate filters under secondary waste streams beginning on page M-9). Empty containers can be disposed of as LLW (see empty containers disposal beginning on page N-1).

Mixed Waste Integrated Program Logic Diagram

Name: Pyridine/Cyanide Waste **MWIR#:** 1051 **Subelement:** Treatment

Matrix: Uncatagorized Aqueous-Organic Liquids / 2190 **Site:** West Valley

Secondary Waste Stream	Treatability Group
Activated carbon material Bottom ash Flyash Offgas particulate filters Scrubber residue Slurry/Sludge	Radiological Constituents: This waste may be classified as a Beta-Gamma emitter and as a contact-handled waste possessing < 10 nCi/g of alpha-emitting radionuclides. Contaminants: This waste stream is contaminated with toxic heavy metals such as chromium and silver. Matrix: This waste consists of sludges, residue, ash, particulate filters, and activated carbon material.

Mixed Waste Integrated Program Logic Diagram

Name: Pyridine/Cyanide Waste **MWIR#:** 1051 **Subelement:** Treatment

Matrix: Uncatagorized Aqueous-Organic Liquids / 2190 **Site:** West Valley

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
ALTERNATIVE Stabilization/Solidification			
Polyethylene: Polyethylene is an inert thermoplastic material that can be processed at low temperatures. Polyethylene binder and dry waste material are fed through separate calibrated volumetric or loss-in-weight feeders to an extruder. The materials are then thoroughly mixed, heated to a molten condition, and extruded into a suitable mold. On cooling, the mixture forms a solid monolithic waste form. No chemical reaction is required for solidification.	Polyethylene is being developed by the DOE for usage within these types of waste streams. Polyethylene has been utilized previously to stabilize scrubber residues. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual constituents contained within the waste stream. The technology needs development on the treatment of shredded particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).
Sulfur Polymer Cement (SPC): Sulfur Polymer Cement is composed of 95% sulfur. It melts at approximately 110 to 120°C and is particularly applicable to the immobilization of toxic metals and treatment of incinerator ash.	SPC is being developed by the DOE for usage within these types of waste streams. SPC has been demonstrated on ash. SPC is not compatible with waste streams that contain high nitrates. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual constituents contained within the waste stream. The technology needs development on the treatment of shredded particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see concentration of soluble salt in the characterization subelement beginning on page M-12). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).
Chemically-bonded Ceramics (CbC): Chemically-bonded ceramic waste forms are produced by mixing the wastes and inorganic oxide binders together. The mixture is then processed at ambient and near ambient temperatures, promoting chemical reactions that bond the waste and the inorganic oxides into a dense ceramic material.	CbC is in early stages for development by the DOE for usage within these types of waste streams. Subsystems required Waste feed system Ingredients feed system Shredder for particulate filters	Technology must be demonstrated on this waste stream to ensure stabilization of toxic constituents and compatibility with the actual constituents contained within the waste stream. The technology needs development on the treatment of shredded particulate filters.	Low power requirements. Few subsystems are required and needed to make use of this technology. Low development risk. <u>Input waste stream characterization information needed</u> The concentration of soluble salt contained in the scrubber residues (sodium, potassium, sulfates, nitrates, and chlorides) (see soluble salt in the char-

Mixed Waste Integrated Program Logic Diagram

Name: Pyridine/Cyanide Waste **MWIR#:** 1051 **Subelement:** Treatment

Matrix: Uncatagorized Aqueous-Organic Liquids / 2190 **Site:** West Valley

Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Chemically-bonded Ceramics (continued)	Projected performance Expected to pass TCLP Expected to produce a suitable final waste form for disposal		acterization subelement beginning on page M-12). <u>Waste streams produced</u> A solidified waste form that requires RCRA LLW disposal (but could also be classified as a RCRA alpha-contaminated LLW waste) (see solidified waste forms disposal beginning on page N-1).

Mixed Waste Integrated Program

Logic Diagram

West Valley
Pyridine/Cyanide Waste
Characterization Technologies

Mixed Waste Integrated Program Logic Diagram

Name: Pyridine/Cyanide Waste **MWIR#:** 1051 **Subelement:** Characterization
Matrix: Uncatagorized Aqueous-Organic Liquids / 2190 **Site:** West Valley

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Concentration of Pyridine.	Alternative/Technology Ion Chromatography (IC)	Accepted by EPA and industry. Ion Chromatography (EPA Method 300.0) is able to quickly and accurately determine analytes in solution to ppm or ppb concentrations. In order to use IC for solids, an extraction method outlined in EPA Method 300.0 must be performed. Additional separation techniques may be needed to further separate ionic species.	None, with proper sample preparation.	Instrument(s) available.
pH of waste.	Alternative/Technology Electrometric	Accepted and proven technology. This method (EPA Method 150.1) is applicable to aqueous wastes and is determined electrometrically using either a glass electrode in combination with a reference potential or a combination electrode. The pH can also be continuously monitored per EPA Method 150.2.	None.	Method(s)/Instrument(s) available.
Presence and concentration of suspended solids.	There is no technology to determine the presence and concentration of suspended solids.	EPA has developed laboratory procedures to determine the presence and concentration of suspended solids of waste material. These procedures are: EPA Method 0160.2 entitled "Total Suspended Solids" in EPA report 600/4-79-020	None.	Method(s) available.
Presence and concentration of oil and grease.	There is no technology to determine the presence and concentration of oil and grease.	EPA has developed laboratory procedures to determine the presence and concentration of oil and grease in waste material. These procedures are: EPA Method 413.1 (Gravimetric, Separatory Funnel Extraction) EPA Method 413.2 (Spectrophotometric Infrared)	None.	Method(s) available.

Mixed Waste Integrated Program Logic Diagram

Name: Pyridine/Cyanide Waste **MWIR#:** 1051 **Subelement:** Characterization

Matrix: Uncatagorized Aqueous-Organic Liquids / 2190 **Site:** West Valley

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Chemical Oxygen Demand (COD) analysis of waste.	Chemical Oxygen Demand (COD) determines the quantity of oxygen required to oxidize the organic matter in a waste sample, under specific conditions of oxidizing agent, temperature and time. There is no technology to determine COD.	EPA has developed laboratory procedures to determine COD of waste material. These procedures are: EPA Method 410.1 (Titrimetric, Mid-Level) EPA Method 410.2 (Titrimetric, Low-Level) EPA Method 410.3 (Titrimetric, High-Level for Saline Waters) EPA Method 410.4 (Colorimetric, Automated; Manual)	None.	Method(s) available.
Concentration of metal salts (especially silver salts).	Alternative/Technology Atomic Absorption (AA), Furnace Technique	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following method to determine the concentration of silver in wastes: EPA Method 272.2 - silver (detection limit 0.2 ug/L)	None, with proper sample preparation.	Method(s)/instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Simultaneous background corrections must be made for all metals to avoid erroneously high results.
	Alternative/Technology Atomic Absorption (AA), Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.2). EPA has approved the following method for determining the concentration of silver metal in wastes: EPA Method 273.1 - silver (detection limit 0.002 mg/L)	None, with proper sample preparation.	Method(s)/instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required.
	Alternative/Technology Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry (ICP-AES)	Accepted. ICP-AES primary advantage is that it allows simultaneous or rapid sequential determination of many elements in a short time. ICP-AES (see EPA Method 200.7) is applicable to all matrices including soils, sludges, and sediments. However, each of these media require significant sample preparation such as acid digestion or dissolution prior to analysis.	None, with proper sample preparation. This is a well-developed technology.	Method(s)/instrument(s) available. Use of ICP-AES (EPA Method 200.7) is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences. Users must verify the absence of spectral interference from an element in a sample for which there is no instrument detection channel (false analyte concentrations may arise - see Table 2, EPA Method 200.7).

Mixed Waste Integrated Program Logic Diagram

Name: Pyridine/Cyanide Waste **MWIR#:** 1051 **Subelement:** Characterization

Matrix: Uncatagorized Aqueous-Organic Liquids / 2190 **Site:** West Valley

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Inductively-Coupled Plasma Spectroscopy Atomic Emission Spectrometry(continued)	The primary disadvantage of ICP-AES is background radiation from other elements and the plasma gases. Although all ICP-AES instruments utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Physical interferences such as samples containing high dissolved solids or high acid concentrations can cause significant inaccuracies. This can be reduced by diluting the sample using a peristolic pump, or by using the standard additions method. EPA Method 200.7 - silver (detection limit 0.002 mg/L.		
	Alternative/Technology Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8). EPA Method 200.8 - silver (detection limit 0.05 ug/L)	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation.	Method(s)/Instrument(s) available.
	Alternative/Technology Ion Chromatography (IC)	Accepted by EPA and industry. Ion Chromatography (EPA Method 300.0) is able to quickly and accurately determine anions in solution to ppm or ppb concentrations. In order to use IC for solids, an extraction method outlined in EPA Method 300.0 must be performed. Additonal separation techniques may be needed to further separate ionic species. Estimated minimum detection limits for the anions of interest are as follows: EPA Method 300.0 - fluoride (detection	None, with proper sample preparation.	Instrument(s) available.

Mixed Waste Integrated Program Logic Diagram

Name: Pyridine/Cyanide Waste **MWIR#:** 1051 **Subelement:** Characterization
Matrix: Uncatagorized Aqueous-Organic Liquids / 2190 **Site:** West Valley

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	Ion Chromatography (continued)	limit 0.01 mg/L) EPA Method 300.0 - chloride (detection limit 0.02 mg/L) EPA Method 300.0 - nitrate (detection limit 0.002-0.004 mg/L) EPA Method 300.0 - sulfate (detection limit 0.02 mg/L)		
Presence and concentration of cyanide.	Alternative/Technology Titration	Accepted by EPA. This technique (EPA Method 335.2) is applicable to the determination of total cyanide in aqueous wastes. The cyanide as hydrocyanic acid (HCN) is released from cyanide complexes by means of a reflux-distillation operation and absorbed in a scrubber containing sodium hydroxide solution. The cyanide ion in the absorbing solution is then determined by volumetric titration or colorimetrically. The estimated minimum amount of cyanide detected by this method is 0.02 mg/L.	None. Proven technology.	Method(s)/Instrument(s) available. Sulfides adversely affect the colorimetric procedure. However, if sulfides are present, they can be precipitated out of the sample.
	Alternative/Technology Colorimetry, Automated UV	Accepted by EPA. This technique (EPA Method 335.3) is applicable to the determination of total cyanide in aqueous wastes. The cyanide as hydrocyanic acid (HCN) is released from cyanide complexes by means of UV digestion and distillation. Cyanides are converted to cyanogen chloride by reactions with chloramine-T which subsequently reacts with pyridine and barbituric acid to give a red-colored complex. The estimated minimum amount of cyanide detected by this method is 5 ug/L.	None. Proven technology.	Method(s)/Instrument(s) available. Sulfides adversely affect the colorimetric procedure. However, if sulfides are present, they can be precipitated out of the sample.
Concentration of soluble salt (sodium, potassium, sulfates, nitrates, and chlorides).	Alternative/Technology Atomic Absorption (AA), Direct Aspiration	Accepted. Samples must be converted to suitable solutions for analysis (see EPA Method 200.0). EPA has approved the following methods for determining the concentration of potassium and sodium in wastes: EPA Method 258.1 - potassium (detection limit 0.01 mg/L) EPA Method 273.1 - sodium (detection limit 0.002 mg/L)	None, with proper sample preparation. This is a well-developed technology.	Method(s)/Instrument(s) available. Care must be taken to minimize the loss of volatile metals during sample preparation. Nonspecific absorption and light scattering can be significant at the analytical wavelengths of these metals. Thus background correction is required.

Mixed Waste Integrated Program Logic Diagram

Name: Pyridine/Cyanide Waste **MWIR#:** 1051 **Subelement:** Characterization

Matrix: Uncatagorized Aqueous-Organic Liquids / 2190 **Site:** West Valley

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	ICP-AES (continued)	EPA Method 200.7 - potassium (detection limit 0.3 mg/L) EPA Method 200.7 - sodium (detection limit 0.03 mg/L)		
→	Alternative/Technology Inductively-Coupled Plasma Mass Spectrometry (ICP-MS) →	Accepted by EPA. Provides multi-element analysis that is more selective than ICP-AES. Allows isotopic analysis. Interferences may occur in elements with similar mass. Common molecular ion interferences in ICP-MS are listed in Table 2 of EPA Method 200.8). →	None, with proper sample preparation. Aqueous or solid samples may be analyzed. Solids require suspension of analytes of interest using techniques such as laser ablation. →	Method(s)/Instrument(s) available.

Mixed Waste Integrated Program

Logic Diagram

Disposal Options

Mixed Waste Integrated Program Logic Diagram

Name: <u>Disposal</u>

Matrix: <u>All</u>

Waste Stream

<u>Waste Stream Description</u>

All residuals generated from the treatment of wastes will require disposal in an appropriate disposal facility. These treatment residuals may be classified as transuranic wastes, low-level wastes, or alpha-contaminated low-level wastes (also known as 'reclassified low-level waste'). These treatment residuals may be comprised of solidified wastes, solidified salts (from various off-gas treatment systems), metal drums and/or other waste containers. Disposal of mixed waste (waste that exhibits RCRA hazardous as well as radioactive attributes) is governed by stipulations contained in EPA-approved (or an EPA-authorized state agency) RCRA permits as well as by stipulations contained in DOE Orders and/or NRC license provisions. Disposal facilities that dispose of RCRA-regulated hazardous wastes are ultimately responsible for determining and certifying that they meet applicable RCRA standards.

The Hazardous and Solid Waste Amendments (HSWA) of 1984 required the EPA to develop treatment standards for all listed and characteristic hazardous wastes. These treatment standards were developed to designate restrictions/limits on allowable disposal concentrations for specific waste contaminants/characteristics. These limits were derived from toxicological data and are considered to be protective of human health and the environment.

Currently, the EPA defines treatment standards via the following:
1) Treatment standards are expressed as limits, with respect to a contaminant concentration within a body of waste.
2) Treatment standards are expressed as limits, with respect to a contaminant concentration within a waste's leachate. 'Contaminants' with regard to hazardous wastes are defined as those constituents contained within a waste leachate that have concentrations exceeding EPA's regulatory limits, specified in 40 CFR Part 261. The limits applicable to constituents contained within a waste's leachate are only applicable to a leachate that has been generated via the EPA's Toxicity Characteristic Leach Procedure (TCLP).
3) Treatment standards are also expressed by requirements dictating that certain types of wastes be subjected to EPA-specified treatment technologies. These EPA-specified treatment technologies are termed 'Best Demonstrated Available Technologies' (BDATs). The EPA's BDAT treatment technology selection is based upon an evaluation of commercially available waste treatment technologies, that are capable of reducing the threat to human health and/or the environment, that is posed by the waste during its presence in a disposal facility.

The use of BDAT treatment standards does not force waste treatment via a specific treatment or technology. Alternate treatment technologies may be used if it can be demonstrated that they are able to meet EPA's applicable treatment standards [as defined in the text above in notes 1) and 2)].

HAZARDOUS DEBRIS
A waste that is classified as a hazardous debris is defined as 1) a solid material exceeding a 60 mm (2.5 inch) particle size that is a manufactured object, plant or animal matter, or a natural geologic material; and 2) a material that exhibits the characteristic of a hazardous waste (as defined by RCRA in 40 CFR Part 261) and/or is contaminated with an EPA-listed hazardous waste contaminant (as defined by RCRA in 40 CFR Part 261); and 3) a material that has been discarded or is intended for discard.

'Contaminants' with regard to debris wastes are defined as those constituents contained within a waste's extract/leachate having contaminant concentrations exceeding their respective regulatory limits, as defined by the EPA under RCRA. These limits are applicable to constituents contained within a waste's extract/leachate, provided the extract/leachate is generated via the EPA's Extraction Procedure Toxicity Characteristic test (EP TOX test) or the EPA's Toxicity Characteristic Leaching Procedure (TCLP), respectively.

Hazardous wastes that are classified as 'hazardous debris' are subject to the LDR prohibitions. Before a hazardous debris can be disposed of, hazardous debris 1) must be treated by EPA-designated waste treatment technologies that have been deemed applicable to debris wastes; or 2) must be treated to meet EPA-specified treatment standards that are applicable to all EPA-listed waste contaminants and/or waste characteristics associated with that particular waste.

EPA has identified seventeen BDAT treatment technologies deemed to be applicable to hazardous debris. EPA has matched debris waste treatment technologies with certain types of debris waste, based upon the composition of a waste's substrate and the contaminants that are present on or embedded within that substrate.

With the exception of using immobilization/stabilization waste treatments, the consequences of using EPA-specified BDAT waste treatment technologies upon debris wastes are two-fold: 1) The treated debris would no longer be considered to be or contain a hazardous waste, (provided that the treated debris does not exhibit any hazardous waste characteristics and that EPA-specified destruction or extraction technologies are used for all types of debris and contaminants contained within the waste matrix); 2) Since treated debris is no longer considered to be a hazardous waste, it is not required that the debris be disposed in a RCRA Subtitle C [RCRA Part B-permitted] disposal facility.

The EPA has determined that debris wastes treated with an immobilization/stabilization treatment technology are not excluded from Subtitle C regulation; because the contaminants have not been destroyed or removed, but rather contained indefinitely. Further, performance standards for immobilized debris have not yet been established. The only requirement placed upon a hazardous debris that has been treated by an immobilization/stabilization treatment technology, is that the likelihood of migration of toxic contaminants has been substantially reduced, or that the leachability of the hazardous contaminants is reduced. There is no requirement that an immobilized/stabilized hazardous debris waste must pass EPA's toxicity characteristic (or other similar) leaching procedure test.

Mixed Waste Integrated Program Logic Diagram

Name: Disposal

Matrix: All

Waste Stream

Various types of immobilization technologies have been selected for treatment of the DOE debris wastes discussed in this document. Types of debris considered in this analysis included wastes comprised of combustibles; mercury-contaminated asbestos; mercury-contaminated carbon filters; filters contaminated with hazardous-metals particulate; waste containers that are no longer intact (e.g., crumpled, broken or ruptured drums); and various pieces of metal (excluding lead bricks). Note: Lead bricks are specifically excluded from being defined as a debris waste by the EPA and therefore, must be disposed of as a hazardous waste or decontaminated and recycled/re-used.

PROBLEMS PRESENTED BY THE WASTE STREAM

The lack of adequate chemical (e.g., types of contaminants) and physical (e.g., size and composition of waste objects) characterization data on mixed and radioactive waste streams present significant impediments to identifying disposal options. Because physical characterization data is lacking, specific contaminant concentration limits are assumed to be applicable to meet LDRs when, if additional characterization data were available, the use of the debris rule may be more appropriate when disposing of certain types of wastes.

Alpha-contaminated low-level waste (reclassified low-level waste) contains transuranic radionuclides with concentrations ranging from 10-100 nCi/g, and cannot be disposed of at facilities that can accept either low-level wastes (< ~ 10 nCi/g) or transuranic wastes (> 100 nCi/g). Treatment of alpha-contaminated wastes may concentrate the radioactivity level within the wastes, resulting in treatment residuals which would have to be managed as transuranic waste. No disposal facilities are available in either the private sector or the DOE complex for such transuranic treatment residuals or for the alpha-contaminated low-level waste from which they are derived.

For purposes of this analysis, it is assumed that all waste requiring disposal meets the applicable EPA treatment standards and disposal requirements, and may therefore be disposed of as-received from offsite generators and/or treatment facilities.

Specific phrases used throughout this analysis have been defined below:
Commercial low-level radioactive mixed-waste disposal facility permits are facility- and isotope-specific. Commercial disposal facilities generally accept waste containing selected radionuclides with concentrations < ~ 10 nCi/g.

DOE's definition of low-level waste is facility-specific. The definition depends upon the results of a "performance assessment", which evaluates the characteristics of the wastes to be disposed and the waste containment characteristics of the selected disposal facility. DOE facilities generally define low-level waste as waste which contains radionuclides in a total concentration of < ~ 10 nCi/g and define alpha-contaminated low-level waste (also known as reclassified low-level waste), as wastes which contain radionuclide concentrations in the range of 10-100 nCi/g.

DOE Orders define transuranic waste as waste that contain elements whose atomic number is > 92 with concentrations > 100 nCi/g.

In 21 states the U.S. Nuclear Regulatory Commission (NRC) is responsible for issuing disposal facility licenses for radioactive wastes. In the other 29 states, the NRC has delegated these responsibilities to the respective state government agencies.

Mixed Waste Integrated Program Logic Diagram

Name: Disposal

Matrix: All

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Empty containers Metal debris	COMMERCIAL LOW-LEVEL WASTE DISPOSAL FACILITY Commercial low-level waste disposal facilities dispose of low-level radioactive wastes. Commercial low-level waste disposal facility permits are issued by the NRC or by NRC-authorized state government agencies. These permits are facility- and isotope-specific. Commercial disposal facilities can generally accept waste containing selected radionuclides with a concentration of < ~ 10 nCi/g.	Commercial low-level waste disposal facilities are available to 'Compact State' waste generators needing to dispose of low-level alpha-, beta- and gamma-contaminated wastes. In most cases commercial low-level waste disposal facilities can dispose of radioactive incineration residuals, fly ash and wastes generated from the operation of pollution-control equipment. The specific types of wastes accepted by each facility is identified in its waste acceptance criteria, which is dictated by the facility's licenses/permits. Disposal, monitoring, and closure technologies for this type of waste disposal facility are well established. Commercial low-level waste disposal facilities exist and are operational. Performance data on commercial low-level waste disposal facilities is not available. Commercial low-level waste disposal facilities are located at Barnwell, South Carolina; Richland, Washington; Beatty, Nevada; and Clive, Utah. The status of each facility is summarized as follows: - Barnwell, South Carolina: This facility can accept waste from states who are making progress on their own disposal sites until July 1, 1994. Thereafter, it will only accept waste from within the Southeast compact. - Richland, Washington: This facility no longer accepts wastes from outside the Northwest and Rocky Mountain compacts. - Beatty, Nevada: This facility was closed on January 1, 1993. - Clive, Utah: This facility recently entered into a contract with the DOE to dispose of a broad range of low-level alpha-, beta- and gamma-contaminated radioactive wastes.	No science or technology requirements need to be resolved to dispose of wastes at commercial low-level waste disposal facilities.	Commercial low-level waste disposal facilities are oriented toward serving a clientele of government agencies, universities, research institutions and hospitals. Operating permits reflect the waste types and radionuclides that these generators produce. Allowable radionuclides and concentration acceptance criteria are established in facility-specific permits. In general, commercial low-level waste disposal facilities accept common radionuclides in concentrations < ~ 10 nCi/g. The process of permitting and constructing commercial low-level waste disposal facilities requires government and public support. In order to facilitate disposal of waste at these facilities, DOE definitions of low-level and transuranic wastes should be made consistent with NRC regulatory language. Commercial disposal facilities may need to modify their operations and revise permits to enable acceptance of low-level DOE wastes.

Mixed Waste Integrated Program Logic Diagram

Name: Disposal

Matrix: All

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
Stabilized glass Slag Solidified waste forms	DOE LOW-LEVEL WASTE DISPOSAL FACILITY DOE low-level waste disposal facilities dispose of low-level radioactive wastes. DOE Orders define and govern disposal of these wastes and establish standards for allowable isotopes and their respective levels of radioactivity. Although the DOE generally defines low-level waste as that waste which contains radionuclides in concentrations < ~ 10 nCi/g, the DOE's definition of low-level waste is facility-specific. This definition is derived from information gathered in a DOE Site's 'Performance Assessment'. The Performance Assessment identifies the types of wastes to be disposed and the waste containment characteristics of the selected disposal facility.	In most cases DOE low-level waste disposal facilities are available to dispose of low-level alpha-, beta- and gamma-contaminated wastes. These facilities can dispose of radioactive waste incineration residuals, fly ash and wastes generated from the operation of pollution control equipment. Disposal, monitoring, and closure technologies for this type of waste disposal facility are well established. Performance data on DOE low-level waste disposal facilities is not available.	No science or technology requirements need to be resolved to dispose of wastes at DOE low-level waste disposal facilities.	DOE low-level waste disposal facilities exist and are operational. Waste streams to be disposed need to be identified. Waste meeting the disposal criteria for a DOE low-level waste disposal facility may also be able to be disposed at a commercial low-level waste disposal facility.
	COMMERCIAL RCRA LOW-LEVEL WASTE DISPOSAL FACILITY Commercial RCRA low-level waste disposal facilities dispose of low-level mixed waste (low-level radioactive waste combined with RCRA hazardous wastes). In addition to obtaining licenses/permits from the NRC (or an NRC-authorized state agency) for disposal of low-level radioactive wastes, these facilities are required to obtain RCRA hazardous waste disposal permits from the EPA (or authorized state agencies) to comply with the regulations of 40 CFR Parts 261-265, governing the land disposal of hazardous wastes.	In most cases commercial RCRA low-level waste disposal facilities are available to dispose of low-level mixed wastes (low-level radioactive wastes combined with RCRA hazardous wastes). The Low-Level Waste Policy Amendment Act of 1985 exempts the DOE from complying with prohibitions applicable to regional low-level waste 'Compacts'; thus, low-level mixed waste from any DOE facility can be disposed at any appropriately licensed/permitted commercial RCRA low-level waste disposal facility. At present, only one commercial facility, Envirocare of Utah, is licensed by an NRC-authorized state agency to dispose of radioactive wastes and is permitted by the EPA for the disposal of RCRA hazardous wastes. This facility is available to dispose of low-level mixed waste incineration residuals, fly ash and wastes generated from the operation of pollution control equipment. DOE wastes from Fernald, Sandia, Pantex, Portsmouth, Paducah and the INEL have been disposed of at	No science or technology requirements need to be resolved to dispose of wastes at commercial RCRA low-level waste disposal facilities.	Commercial RCRA low-level disposal facilities exist and are operational. Waste streams to be disposed of and available disposal facilities need to be identified. Waste then needs to be characterized, as required by applicable commercial disposal facility waste acceptance criteria.

Mixed Waste Integrated Program Logic Diagram

Name: Disposal

Matrix: All

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
		Envirocare of Utah. This disposal facility has recently entered into a contract with the DOE allowing the disposal of a broad range of DOE's low-level mixed wastes.		
	→ DOE RCRA LOW-LEVEL WASTE DISPOSAL FACILITY DOE RCRA low-level waste disposal facilities could be used to dispose of low-level mixed waste (low-level radioactive wastes combined with RCRA hazardous wastes). DOE Orders define and govern disposal of these wastes and establish standards for allowable isotopes and their respective levels of radioactivity. Although the DOE generally defines low-level waste as that waste which contains radionuclides in concentrations < ~ 10 nCi/g, the DOE's definition of low-level waste is facility-specific. This definition is derived from information gathered in a DOE Site's 'Performance Assessment'. The Performance Assessment identifies the types of wastes to be disposed and the waste containment characteristics of the selected disposal facility. These facilities would be required to obtain RCRA hazardous waste disposal permits from the EPA (or authorized state agencies) to comply with the regulations of 40 CFR Parts 261-265, governing the land disposal of hazardous wastes.	DOE RCRA low-level waste disposal facilities do not exist. Such facilities could dispose of low-level mixed wastes (low-level radioactive contaminated wastes combined with RCRA hazardous wastes), such as incineration residuals, empty drums, stabilized glass, personnel protective equipment, fly ash and wastes generated from the operation of pollution control equipment. Waste acceptance criteria would be established and defined via facility-specific performance assessments. It is anticipated that DOE RCRA low-level waste disposal facilities would be able to dispose of radioactively-contaminated wastes having radioactivity concentrations < ~ 10 nCi/g. Status of this disposal technology is conceptual. →	No science or technology requirements need to be resolved to dispose of wastes at DOE RCRA low-level waste disposal facilities. →	DOE RCRA low-level disposal facilities do not exist. Waste streams that could be disposed at such a facility need to be identified. Facilities then need to be permitted and constructed to enable the disposal of these wastes. Waste meeting the disposal criteria for a DOE RCRA low-level waste disposal facility may also be able to be disposed at a commercial RCRA low-level waste disposal facility.

Mixed Waste Integrated Program Logic Diagram

Name: Disposal
Matrix: All

Problem Area	Alternative/Technology	Status	Science and Technology Needs	Implementation Analysis
	DOE RCRA ALPHA-CONTAMINATED LOW-LEVEL WASTE DISPOSAL FACILITY DOE RCRA alpha-contaminated low-level waste disposal facilities would accept and dispose of alpha-contaminated low-level mixed wastes (reclassified low-level radioactive wastes combined with RCRA hazardous wastes). These disposal facilities would be specifically constructed to dispose of waste that is contaminated with alpha-emitting transuranic radionuclides having half-lives greater than 20 years and concentrations in the range of ~ 10-100 nCi/g. In addition to complying with DOE Orders, these facilities are required to obtain RCRA hazardous waste disposal permits from the EPA (or EPA-authorized state agencies) to comply with the regulations of 40 CFR Parts 261-265, governing the land disposal of hazardous wastes.	DOE RCRA alpha-contaminated low-level waste disposal facilities do not exist. Such facilities could dispose of alpha low-level mixed wastes (alpha low-level radioactive contaminated wastes combined with RCRA hazardous wastes) in concentrations < ~ 100 nCi/g. Types of wastes that could be included in this category are incineration residuals, drums, personnel protective equipment, fly ash and wastes generated from the operation of pollution control equipment. Status of this disposal technology is conceptual. Performance data on DOE RCRA alpha-contaminated low-level waste disposal facilities is not available.	No science or technology requirements need to be resolved to dispose of wastes at DOE RCRA alpha-contaminated low-level waste disposal facilities. Adequate disposal technology design criteria, in the form of approved hazardous waste disposal facility construction criteria and DOE low-level waste disposal criteria, already exists.	DOE RCRA alpha-contaminated low-level disposal facilities do not exist. Waste streams to be disposed at such a facility need to be identified. Facilities then need to be permitted and constructed to enable the disposal of these waste streams.
	GEOLOGIC REPOSITORY Geologic repositories are facilities that could dispose of TRU mixed-wastes (transuranic wastes combined with RCRA hazardous wastes). These repositories are constructed in geologic formations deep underground. The DOE's Waste Isolation Pilot Project (WIPP) is such a repository. DOE Orders define transuranic waste as containing elements whose atomic number is > 92 with concentrations > 100 nCi/g. DOE Orders will govern disposal of the transuranic component of these wastes. EPA regulations found at 40 CFR Parts 261-265 govern disposal of the RCRA-regulated hazardous component of these wastes, thus a disposal permit from the EPA (or EPA-authorized state agency) would be required.	The DOE's geologic repository, WIPP, could be an option for the disposal of TRU mixed-wastes (transuranic wastes combined with RCRA hazardous wastes). Types of wastes that could be included in this category are incineration residues, stabilized glass and ash, slags, and other solidified wastes with radioactive concentrations > 100 nCi/g. This disposal technology is awaiting demonstration. WIPP is currently in the process of obtaining a no-migration variance from the EPA and is expected to begin receiving wastes in the year 2000. Performance data on geologic repositories, in the form of performance models, is being gathered by the DOE. Currently, the WIPP waste acceptance criteria dictate that it cannot accept wastes that have been generated from environmental restoration related or non-defense related activities.	No science or technology requirements need to be resolved to dispose of waste at the DOE's geologic repository. The repository has been constructed and is in the process of obtaining permits and approvals that will enable it to commence operation.	Permitting requirements for the WIPP facility must be completed before waste can be accepted for disposal.

Table 1.

SAMPLING OF RADIONUCLIDES FROM

Radionuclide	Chemical and/or Physical Form	Maximum Average Concentration*
Americium	Volumetric bulky materials	0.23 nCi/g
Barium 133	Volumetric bulky materials	4.0 nCi/g
Cobalt 60	Volumetric bulky materials	0.36 nCi/g
Cesium 137	Volumetric bulky materials	0.56 nCi/g
Curium 244	Volumetric bulky materials	10 nCi/g
Lead 210	Volumetric bulky materials	230 nCi/g
Potassium 40	Volumetric bulky materials	10 nCi/g
Plutonium	Volumetric bulky materials	8.2 nCi/g
Plutonium 239	Volumetric bulky materials	9.9 nCi/g
Plutonium	Volumetric bulky materials	10 nCi/g
Plutonium	Volumetric bulky materials	350 nCi/g
Plutonium	Volumetric bulky materials	10 nCi/g
Radium 228	Volumetric bulky materials	1.8 nCi/g
Strontium 90	Volumetric bulky materials	20 nCi/g
Thorium 230	Volumetric bulky materials	15 nCi/g
Uranium	Volumetric bulky materials	18 nCi/g
Uranium	Volumetric bulky materials	110 nCi/g
Uranium 234	Volumetric bulky materials	37 nCi/g
Uranium 238	Volumetric bulky materials	28 nCi/g
Yttrium 90	Volumetric bulky materials	20 nCi/g

* averaged over entire load of waste.