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Oak Ridge K–25 Site Technology Logic Diagram

Volume 2 Technology Logic Diagrams

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U.S. Department of Energy

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Foreword

The Oak Ridge K-25 Technology Logic Diagram (TLD), a decision suppori developed to provide a planning document tnat relates environmental restorati problems at the Oak Ridge K-25 Site to potential technologies that can remedia uses information from the Strategic Road Map for the Oak Ridge Reservation a TLD.

The TLD technique identifies the research necessary to develop these techn for technology transfer and application to waste management, remedial actio decommissioning activities. It is essential that follow-on engineering studies a output of this project. These studies will begin by selecting the most promising TLD and finding an optimum mix of technologies that will provide a socially a cost and risk.

The Oak Ridge K-25 Site TLD consists of four separate volumes—Vol.1 Volume 1 provides introductory and overview information about the TLD. Volum Volume 3 has been divided into two separate volumes to facilitate handling and

This volume contains the Technology Logic Diagrams and an index. The in provided before the diagrams, contains technology names and technology locate specific technologies in Vol. 2.

The technology evaluations that are contained in these volumes are based able during the TLD compilation. New or more accurate information is solicit base. Please FAX comments (615-576-8558) to R. L. Fellows, Editor, Oak Logic Diagram, Martin Marietta Energy Systems, P.O. Box 2003, Oak Ridge, TN

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ɔm (TLD), a decision support tool for the K-25 Site, was
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management, remedial action, and decontamination and
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that will provide a socially acceptable balance between

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ccurate information is solicited to improve the TLD data
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How to Use Volur

The Technology Wiring Diagram shows the logic linkage among the Oak Ridge K-25 Site environmental management (EM) goals, the specific environmental problems that must be solved to meet these goals, and the various technologies that have the potential to solve these problems. The Wiring Diagram relates, through the use of flow chart arrows, the environmental restoration and waste management (WM) problems at the K-25 Site to remedial technologies. The focus of the diagram is on remedial technologies, and the status of each is considered from the standpoint of maturity, improvements over existing approaches, and applicability to specific K-25 Site problems.

Volume 2 is divided into six major sections, or chapters. Each of these major sections contains information that addresses the logic flow in meeting the EM goal. The major sections are: **Characterization-**–analysis of kinds and quantities of contaminants; **Decontamination**–process to remove contaminants and restore materials; **Dismantlement**–removal of contaminated equipment and deconstruction of facilities; **Robotics/Automation**–automated equipment and processes for all other sections; **Waste Management**–handling and disposal of hazardous/toxic materials; and **Remedial Action (RA)**–reconditioning and reclamation of contaminated natural resources.

The diagram flows from left to right, and is composed of columns of input data, or logic elements. Each logic element flows from *EM Goals*. These goals are shared to varying degrees by all sections of the U.S. Department of Energy (DOE) complex. *EM Problem* contains common problem areas agreed upon by EM and DOE, such as decontamination and decommissioning (D&D), soils and ground surface water (RA), and waste management. *K-25 Site Problem* describes the site-specific problems associated with the K-25 Site. *Problem Area/Constituents* contains specific K-25 Site constituents or tangible parts of the problem that must be addressed individually. These problem areas will be formulated differently for each major section of the Technology Wiring Diagram. The *Reference Requirements* element refers the reader to Vol. 1, Chapter 6, *Summary of Regulatory Needs*. Applicable regulations must be determined on a site specific set of factors including exact location and planned mobility of constituent and technology, location characteristics, exact type, quantity, and toxicity of constituents involved throughout the technology process, types and quantities of waste created, and planned manner of transportation, storage, or disposal. *Subelement* specifies one of the categories used to identify the universe of activities necessary to solve a problem. The Subelements are: Characterization, Decontamination, Dismantlement, Materials Disposition, Robotics/Automation, and Regulatory Compliance. *Alternatives* describes the general or generic technological approaches.

Technologies is the focal point of the diagram. This is a compilation of all technologies deemed applicable to solving the EM problem. *Status* is the information concerning the maturity of the technology listed in the prior column. The categories are: Accepted– in common use and directly applicable to the K-25 Site; Demonstration–available but not demonstrated for the K-25 Site problem; Predemonstration–under laboratory development; and Evolving Technology–technology that is at conceptual or preconceptual stage (some scientific or knowledge basis only). *Science/Technology Needs* indicates areas that are related to the fundamental understanding of the scientific phenomena underlying the basis for the technology. *Implementation Needs* relates to improvements that make current technology safer, more economical, effective, or efficient.

Each technology has been prioritized according to the probability of its making significant contributions to the D&D, RA, and WM efforts at the K-25 Site. Three categories are indicated on the diagrams by arrows as follows: high probability (▬▬), medium probability (▬▬), and low probability(———).

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se Volume 2

Uses of the Technology Logic Diagram: Examples

- To find all of the possible technology tools that are considered to have the most potential for characterization work at the K-25 Site:
  - Turn to the Characterization section of this volume.
  - Scan each page under the column *Technology* for the listing of technologies.
    The technology names preceded by the boldest arrows have the most potential. (Those with the least potential have the least bold arrow.)
- To find all of the decontamination technologies that remove only transferrable contamination from surfaces:
  - Turn to the Decontamination section of this volume.
  - Under the Alternatives, or generic technology, column find the category *Surface Cleaning* (transferrable contamination).
    All linked technologies in the adjacent Technologies column will remove transferrable contamination.
- To find information about a specific technology:
  - Refer to the index (starting on the next page) to locate the page number from the technology name.
  - Turn to the indicated page(s) to acquire detailed information about that technology. Scientific and technical literature references and more detailed information can be obtained by cross referencing the technology number to Vol. 3.
- For example, to locate information on plasma arc saw cutting of equipment:
  - Locate this technology in the index by name or technology number.
  - The page numbers for this technology are located immediately under *plasma arc saw*, and indicates the pages (Section 3, pages 4 and 11) on which detailed information can be found in Vol.2.
- To find out what can be done with contaminated oil:
  - Refer to the index at the end of this section.
  - Notice that the index lists *contaminated oil* as being in the Waste Management section, pages 6.3-18 through 6.3-27. These pages contain the various technologies considered appropriate for remediating the contaminated oil problem.
- To determine how to implement a method to remove Tc from groundwater:
  - Find *groundwater* in the index of this volume.
  - Notice that the index lists Tc in groundwater, on pages 4-11 and 4-12 of the Remedial Action section. Adsorption and ion exchange are two technologies listed for Tc removal. The Status, Science/Technology Needs, and Implementation Needs columns give information on development efforts required for these technologies.

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Containment:
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Characterizat

The Characterization section is grouped into several subsections under the Alterna Collection, Sampling, In-Situ Characterization, Laboratory Characterization, and Data ings of General, RAD, Inorganic, and Organic Contamination.

K-25 Site problem areas were grouped to reflect common characteristics in terms (Characterization needs particular to environmental restoration activities are covered u headings.For this preliminary volume, the technologies are listed only once, so that te heading "General." Technologies with potential in-situ application are covered in the ir laboratories.

:terization

ıder the Alternatives column. These subsections are: Statistics and Data
ation, and Data Assessment. Each of these was discussed under the head-

istics in terms of size, complexity, accessibility, and expected contaminants.
; are covered under Soils and Groundwater, Burial Waste, and Pond Waste
ınce, so that technologies with several applications are covered under the
:overed in the in-situ section, even though they may be more widely used in

Technology Logic
Characterization

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Sub Elements	Alternatives
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Buildings Process Support Buildings Cooling Towers Electrical and Electrical Switch Gear Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities	General Use: These technologies can be used to perform a wide variety of characterizations and thus are not directed towards a specific problem area/constituent (see text for more detail)	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Characterization	Statistics; Data Collection Sampling, Sample Prep

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Notes:

∆ Indicates Technology Expected To Be Particularly Useful In Support Of Decontamination & Dismantlement Activities.

√ Indicates Robotics/Automation Potential

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Alternatives	Technologies	Status	Science Technology Needs	Implementation Needs
Statistics; Data Collection	Optimization of Sampling Designs √ CHAR-71-OG	**Demonstration** Appropriate sampling designs can prevent obtaining too little information or spending too much money on a more than adequate number of samples. Current LANL work.	Literary searches for finding useful sampling designs from other fields. Development of new statistical methods for sampling design.	Development costs $150K
	Hadamard Masking for Spatial Resolution √ CHAR-28-OG	**Demonstration** Allows spatial resolution or multiplexing measurements to be made with a single channel detector. Higher signal-to-noise ratio than with a single point mask; allowing better sensitivity.	Mask designs and collimators for specific applications. Determination of scattering effects for RAD measurements.	Masks for adaptation of radiological counters for large area analysis. Development costs $200K.
	Database Mgmt. for Large Data Collections √ CHAR-72-OG	**Accepted** Storage and retrieval of large amounts of data in a cost-effective manner will allow the collection and ready retrieval of all characterization data. This would present full characterization data to cleanup organizations, allowing more detailed screening characterization, or would ensure that expensive characterization data is not duplicated unnecessarily, as well as allowing for tracking and trending.	Procedures will need to be developed that will ensure maximum access to the data while ensuring its integrity. Adaptation of existing software to allow for statistical manipulation and visual display.	HP and analytical databases exist on Site. Development costs $200K.
	Visual Display Of Statistical Information CHAR-73-OG	**Pre-Demonstration** Integration of statistics software and database system with graphics display capability. Current LANL work.	Geographic Information System software is available which comes close to meeting this need. This system would need to be adapted for characterization use. 3-D GIS.	Optimization of computing capacity. Development costs $500K.
	Statistical Methods for Spatially Correlated Data √ CHAR-75-OG	**Accepted** The use of spatial statistics and kriging (geostatistics) has been demonstrated successfully for years in the mining and petroleum industries. Current LANL work.	Adaptation from the mining and petroleum industries for use in site characterization. Easy to use kriging software will need to be found or developed.	Optimization of computing capacity. Development costs $300K.
	Artificial Intelligence/Neural Network √ Δ CHAR-22-OG	**Accepted/Demonstration** Allows control of instrumentation, data and interpretive analysis based upon human logic with the processing power and repetitive capabilities of computerized systems. It could enable characterization work to be performed to be optimized on a real-time basis. Also useful for training.	Software and model development for data interpretation; including trending on a real-time basis.	Optimization of computer systems depending on sophistication needed for specific applications. Development costs $500K.
Sampling, Sample Prep	Membrane Technology for Sample Collection & Concentration CHAR-55-OG	**Demonstration** Potentially effective in many characterization and decontamination scenarios, particularly including waste stream monitoring. Technology has been demonstrated for environmental monitoring, but is not yet accepted by EPA.	System development or adaptation for specific applications; validation.	Sample collection systems for site-specific applications. Development costs $200K.
	Continuous Air Monitoring Δ CHAR-59-OG	**Accepted.** Widely used; accepted by EPA.	Protocols to provide direct support to specific D&D needs.	Development costs $500K.
	Sensor Delivery Systems CHAR-120-OG	**Accepted.** Cone Penetrometer System (SCAPS) demonstrated at SNL	See robotics and automation.	See robotics and automation.

Technology Lo
Characteriz

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

- Enrichment Process Buildings
- Process Support Buildings
- Cooling Towers
- Electrical and Electrical Switch Gear
- Pumping Stations
- Laboratory Facilities
- Special Development Facilities
- Administrative Facilities

→ General Use: (cont.) → Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified. → Characterization (cont.) → Sampli Sampl (cont.)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

Logic Diagram
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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Sampling, Sample Prep (cont.)	Multi-Angle Drilling For Depth Profiling CHAR-64-OG	**Demonstrated** Allows collection of samples for composition depth profiling in cases where core drilling is not possible.	Development - Need to conduct model studies based upon site specific needs.	Standard drilling equipment can be tailored for specific applications. Development cost $100K.
	Metallographic Sample Preparation CHAR-67-OG	**Accepted** Widely used method to prepare representative cross-sections of materials. Valuable for contaminant spatial (particularly depth) distribution determinations.	Needs procedure and protocol development for specific matrices and applications.	**Development Costs:** 1K-30K, depending on application.
	Ultrasonic Extraction CHAR-20-OG	**Pre-Demonstration** Ultrasonic extraction is a widely used and EPA approved laboratory extraction technique. The technique could be adapted to more efficient sampling of porous media surfaces.	Development - Need to adapt flow through extraction cell for surface sampling, test solvents, acids and bases for extraction efficiency, and validate the method.	Adaptation for specific geometries. **Equipment:** $4-4K **Development Costs:** $250K
	Laser Ablation CHAR-86-OG	**Demonstration** Technique for sampling solid materials by ablating the surface followed by analysis of the removed material. Currently used in ICP-MS. This technology is becoming available for field and more general laboratory use (see CHAR-SYL-01).	Need to develop sampling equipment, procedures and protocols for specific field and laboratory applications.	**Development Costs:** $100K **Equipment:** $200K
	Correlation Of Matrix Porosity with Collection Efficiency: Standardize Methodology CHAR-61-OG	**Conceptual.** These studies would allow variations in collection efficiency as a function of the porosity of the host matrix to be understood, this would allow better correlation of data sets from various structural components.	Model studies and field tests to determine the effect of porosity. Protocols developed to ensure uniform interpretation of contaminant concentrations.	Sample collection and analysis program to identify suspect sampling scenarios. **Development Costs:** <$50K
	Laser/Flashlamp Heating √ CHAR-87-OG	**Pre-demonstration** Potentially rapid method for surface and subsurface sampling for contaminants, particularly useful for robotic and sensor applications.	Determination of sampled region and sampling effectiveness for specific contaminant/matrix systems.	To be determined for specific applications. **Development Costs:** >$50K
	Vacuum Assisted, Reverse Flow Solvent Extraction Methods CHAR-62-OG	**Conceptual.** Solvent is introduced through a drill hole into a porous host matrix and a vacuum device is is used to recover solvent plus contaminant through the host matrix.	Laboratory studies for assessment of collection efficiency; and development of portable sampling systems.	**Development Costs:** $400K.
	Sampling & Mixing Methods CHAR-81-OG	**Demonstration** Standard procedures using portable field units are needed to "mix" particulate matter quickly and effectively. Protocols for assessment of non-homogeneous wasteforms have not yet been developed.	Development of protocols for the quantitative evaluation of homogeneity; assessment of commercially available and the probable development of portable mixing equipment. Procedures have been developed for individual applications; these could be expanded for more general use.	**Development Costs:** $300K for mixing; $300K for protocols. **Equipment:** 15K.
	Microwave Digestion CHAR-19-OG	**Accepted** Effective in digesting and extracting trace elements form soils and complex matrices prior to analysis. This is an emerging technology that shows much promise in reducing the amount of waste produced in sample analysis as well as increasing the quality of the data obtained.	Adaptation and optimization for specific applications.	**Capital Equipment Costs:** $22 to 50K per instrument **Operating Costs:** <$25 per test

Technology Logic
Characterization

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

K-25 Site Problem

- Enrichment Process Buildings
- Process Support Buildings
- Cooling Towers
- Electrical and Electrical Switch Gear
- Pumping Stations
- Laboratory Facilities
- Special Development Facilities
- Administrative Facilities

Problem Area/Constituents

General Use: (cont.)

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelements

Characterization (cont.)

Alternatives

- Data Assessment,
- In Situ Physical
- Ex Situ Physical (Laboratory)

Data Assessment,	Chemometrics √ CHAR-21-OG	**Accepted** Mature but expanding technology forextraction of trends and components from multi-variant data.	Development - Need to set up models to handle the vast data sets anticipated and to permit real-time analysis of data, as well as robotic input.	Software systems <$10K. Development needs will very. ($25K-200K)
	Auto-Correlation Optimized Multivariant Analysis √ CHAR-29-OG	**Demonstration** Allows spectroscopic data to be analyzed and interpreted with minimum impact from noise, and multi-variant information to be fully utilized.	Development - Need to establish a data base of spectroscopic responses for site-specific applications and rapid analysis capabilities.	Software exists on site. **Development Costs:** $200K
	Statistical Methods For Multivariate Data √ CHAR-74-OG	**Demonstration** Technology approach for understanding multi-variate systems.	Development - New methods needed to aid understanding of multi-variant, multi-constituent contamination.	Normal implementation needs optimized computing capacity: $300K. **Development Costs:** Mainly training of on-site statisticians. Maybe a part of chemometric implementation.
In Situ Physical	Computer Tomography CHAR-41-OG CHAR-60-OG	**Development.** Non-destructive imaging technique for the determination of nuclear waste water content. May be useful in other decommissioning and environmental remediation determinations.	Currently under development. May need adaptation to Site-specific needs.	Computer and instrumentation needs to be determined.
	Holographic Imaging CHAR-46-OG	**Accepted** Technology allows in-situ measurements of stress/strain over large areas, useful for risk assessment in decontamination and removal of large pieces of equipment.	Mature Technology. Develop large scale steam-strain models for full interpretation of Helograms.	need field-portable units for holographic imaging of permanently mounted components. **Development Costs:** $300K
	Laser Scattering Particle Size Analysis Δ CHAR-26-OG	**Accepted.** Commercial equipment available.	Adaptation to allow on-line or real time monitoring of particulates.	More Aggressive Implementation Needed **Development Costs:** $100K **Capital Costs:** $40-100K
	Annular Denuder Technology Δ CHAR-64-OG	**Accepted** No waste/low cost technology accepted for air sampling of contaminants. Could be coupled with automated measurement technolog.	Development - Need to develop technology for enhanced radiological sampling and analysis in the field.	Development and equipment costs uncertain at the present. <$100/sample.
	Fiber Optic Camera Systems CHAR-122-OG	**Accepted** Commercially available.	System resolution and portability improvement persued commercially. Development of hardened camera for hazerdous environments.	Available system cost ~ $40K
Ex Situ Physical (Laboratory)	Transmission Electron Microscopy (TEM) CHAR-34-OG	**Accept** Mature technology in wide-spread use in physical structure and chemical analysis (the latter, in conjunction with other technologies.)	Sampling and protocol development in conjunction with CHAR-DPH-37 and CHAR-HMH-Ø1 and alone.	Available now. Analysis <$500 **Development Costs:** $200K
	Scanning Electron Microscopy (SEM) CHAR-33-OG	**Accept** Mature technology in wide-spread use in physical structure and chemical analysis (the latter, in conjunction with other technologies.)	Sampling and protocol development in conjunction with CHAR-DPH-35,36 and CHAR-HMH-Ø1.	Available now. Analysis <$500 **Development Costs:** $200K per package.
	Computerized Image Analysis CHAR-119-OG	**Accepted** Mature technology in wide-spread use. Particularly useful for homogeneity determination.	Sampling and protocol development in conjunction with CHAR-DPH-35,36 and CHAR-HMH-Ø1.	Available now. Analysis <$500 **Development Costs:** $200K per package.

Technology Lo

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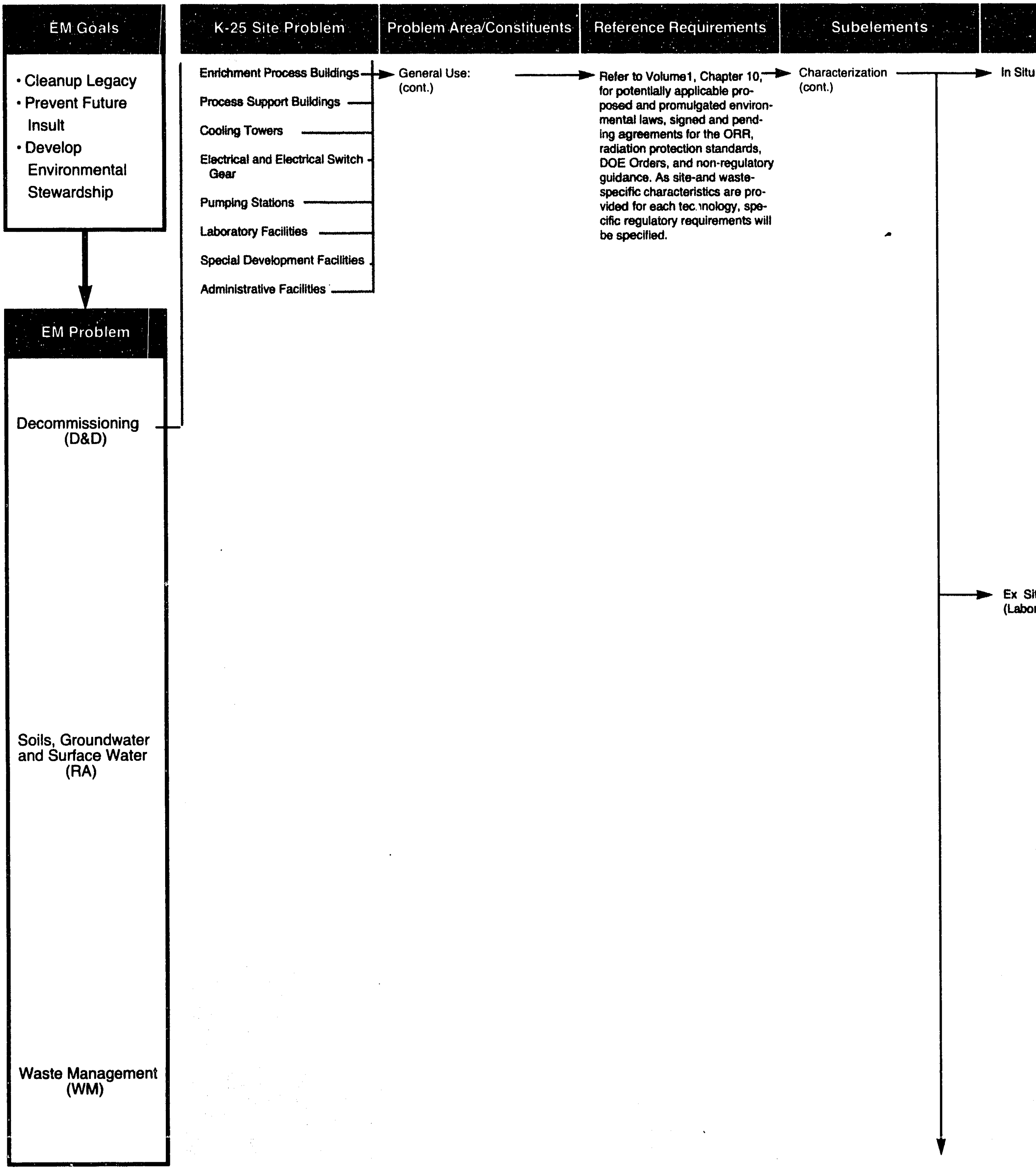

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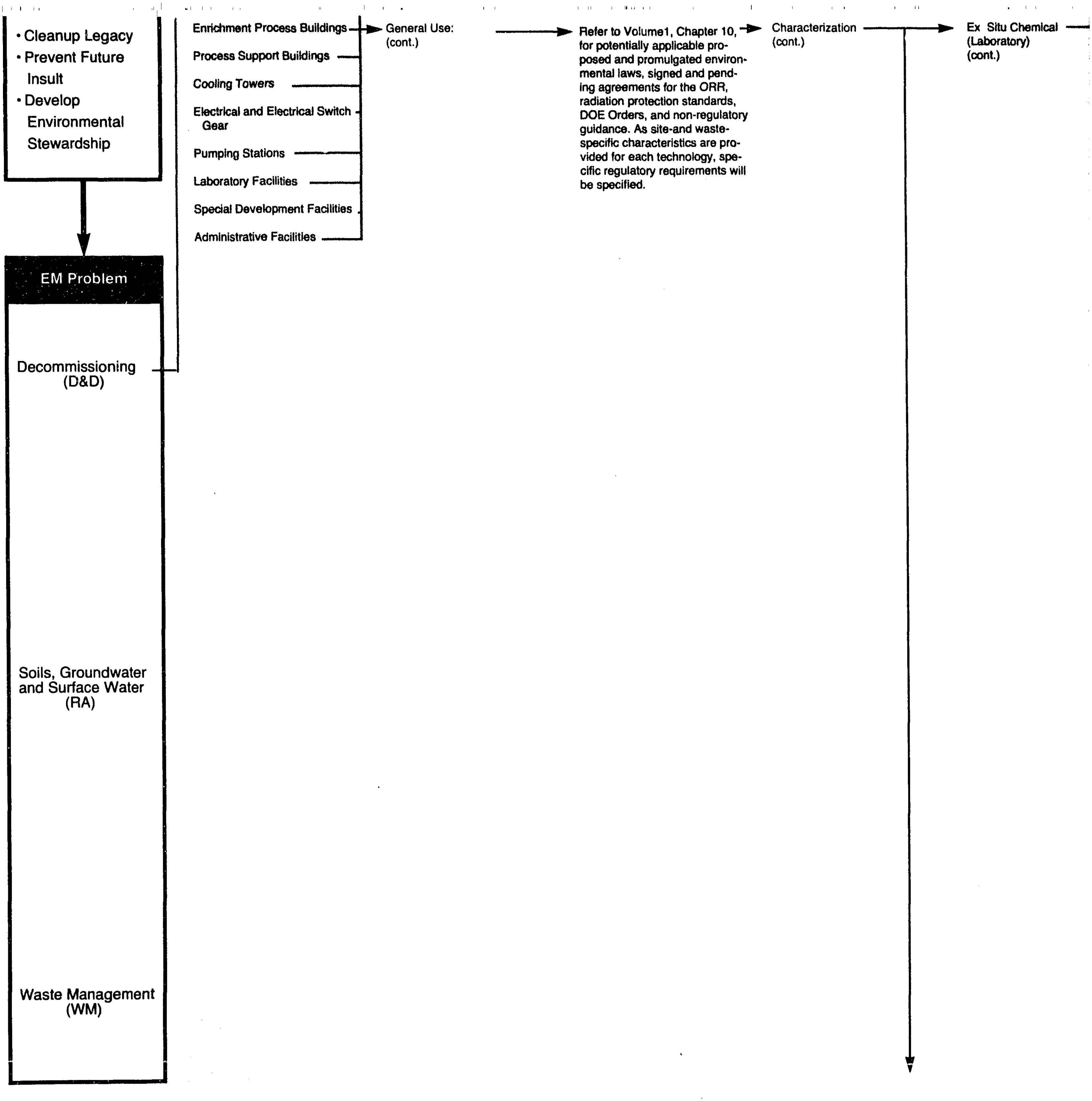
Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
In Situ Chemical	Laser Photo Acoustic Spectroscopy (LPAS, PAS) CHAR-15-OG	**Accepted.** Ppb detection levels for gases or solids.	Specific laser-detection combinations for site-specific needs. Enhancement of portable and in-situ capabilities.	<$99/sample. **Development Costs:**
	Laser Raman Scattering CHAR-87-OG	**Accepted.** Various collection geometrics allow for rapid qualitative and quantitative analysis.	Development of standardized applications and database. Fiber optic delivery systems for field work.	**Instrument Costs:** $300K **Development Costs:** $400K
	Fiber Optic Chemical Sensors √ CHAR-25-OG	**Demonstration** Fiber optic probes can be delivered to remote and limited access locations. Low cost per measurement, no waste.	Development of matched waveguides and analytical techniques which can withstand harsh chemical environments. Development of field portable units.	Development costs $500K. Low cost/measurement.
	Optical Microscopy CHAR-32-OG	**Accepted** Mature technology in wide use.	Development - need to develop site-specific atlas to facilitate rapid identification, and set up field instrumentation.	Normal implementation needs. **Instrument Costs:** @$5K **Development Costs:** @$100K
	Fluorescence √ CHAR-110-OG CHAR-92-OG	**Development** Sensitive technique for many specific applications. Laser technology would enhance sensitivity.	Work with specific contaminants to supplement published fluorescence data. Many off-the-shelf system component items available. Procedures and protocol development. Downsizing for field use. Laser development needed.	**Instrument Costs:** $300K **Development Costs:** $400K
Ex Situ Chemical (Laboratory)	Electron Spectroscopy For Chemical Analysis (ESCA) CHAR-1-OG	**Accepted** Provides elemental and chemical state information on surface species. Mature technology accepted by industry.	Development of specific procedures and protocols.	Instrument and staff available. **Development Costs:** $50K **Operating Costs:** <$500/sample
	Auger Electron Spectroscopy (AES) CHAR-2-OG	**Accepted** Provides elemental and spatial profiling information in the surface region. Mature technology accepted by industry.	Development of specific procedures and protocols.	Instrument and staff available. **Method Development Costs:** @$200K **Operating Costs:** <$500/sample
	Secondary Ion Mass Spectrometry (SIMS) CHAR-3-OG	**Accepted** Mature technology elemental and compound spatially-resolved information. Also U-235/U-238 enrichment characterization. Accepted by industry.	Development:: Need studies of model matrices to calibrate and understand site-specific applications. Quantitative data not readily available for elemental analysis	Instrumentation and staff available within MMES. **Development Costs:** $200K **Operating Costs:** $100-$500 per sample.
	Laser Ionization Mass Spectrometry (LIMS) CHAR-4-OG CHAR-93-OG	**Accepted** Identification of surface elements and compounds with high spatial resolution. Also enrichment information. Accepted by industry.	Development:: Need studies of model matrices to calibrate and understand site-specific applications. Standardized procedures.	Instrumentation and staff available within MMES. **Development Costs:** $200K **Operating Costs:** <$500 per sample.


• Cleanup Legacy
• Prevent Future Insult
• Develop Environmental Stewardship
EM Problem
Decommissioning (D&D)
Soils, Groundwater and Surface Water (RA)
Waste Management (WM)
Enrichment Process Buildings
Process Support Buildings
Cooling Towers
Electrical and Electrical Switch Gear
Pumping Stations
Laboratory Facilities
Special Development Facilities
Administrative Facilities
General Use: (cont.)
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Characterization (cont.)
Ex Situ Chemical (Laboratory) (cont.)

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Ex Situ Chemical (Laboratory) (cont.)	Secondary Neutral Mass Spectrometry (SNMS) CHAR-7-OG	**Accepted** A wide variety of post ionization schemes are currently in use to increase the ion yield. This method of solid state mass spectroscopy has improved quantitative capabilities and would allow accurate U enrichment studies to be performed.	System development and model studies for calibration of enrichment measurements for small particles of U.	**Capital Equipment Costs:** $500K **Development Costs:** $200K
	Chemical Leaching Tests CHAR-113-OG	**Pre-Demonstration** Tests of potential leachability conducted at Fernald.	Science - Need development and validation of site-specific leaching tests.	**Development Costs:** $200K
	Nuclear Magnetic Resonance (NMR) CHAR-11-OG CHAR-58-OG	**Accepted** This mature technology can be applied to both liquid and solid samples (MAS) and can provide imaging information. This technology is very useful for identifying materials as well as studying materials interactions.	Model studies and protocols for adaptation and application of technology.	**Hardware:** $200K-$2M **Development Costs:** $200K-$500K
	X-Ray Diffraction CHAR-31-OG	**Accepted** Provides identification of crystalline phases in solid samples. Can supply quantitative, stress/strain, and particle size information. Mature technology widely used in industry	Development - Need studies of model site-specific samples if quantitative analysis required.	Technology available. **Development Costs:** $100K **Operating Costs:** >$100/sample.
	Electron Diffraction (ED, SAED, LEED) CHAR-37-OG	**Accepted** Mature technology. When used in conjunction with transmission electron microscopy, can provide phase identification of submicron particulates and impurities in host matrix. Asbestos identification. Widely used and accepted by industry.	Development of procedures, quantitative models and database for site-specifi scenarios..	<$200/sample **Development:** $50K
	Isotopic Dilution Mass Spectroscopy (IDMS) CHAR-48-OG	**Accepted** Mature technology. High sensitivity, particularly suited for measurements of levels of fission products (eg, Tc, I) and neutron-capture product at levels as low as 10^7 atoms. Accepted by industry. Technique will give necessary precision for accountability analysis.	Development - Set up to rapidly measure U/Tc ratios to determine extent of Tc at various stages of the cascade equipment.	Instrumentation available. **Development Costs:** $100K
	Electrochemical Methods CHAR-10-OG	**Accepted/Development** There are a wide variety of electrochemical techniques (e.g. electrogravimetry, polarography, coulometry, voltammetry) that can provide chemical and materials interaction information. These techniques could be useful in waste treatment and interaction studies as well as identifying species present in waste streams.	Adaptation and protocols for model studies to be performed on complex systems.	**Hardware:** $50K-$250K **Development Costs:** $250K

Technology Lo

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Buildings Process Support Buildings Cooling Towers Electrical and Electrical Switch Gear Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities	General	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Characterization	Ex Situ (Labor (cont.)
		Radioactive Elements (U, Tc) These technology are optimized for characterizing radiological materials.	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Characterization	In Situ

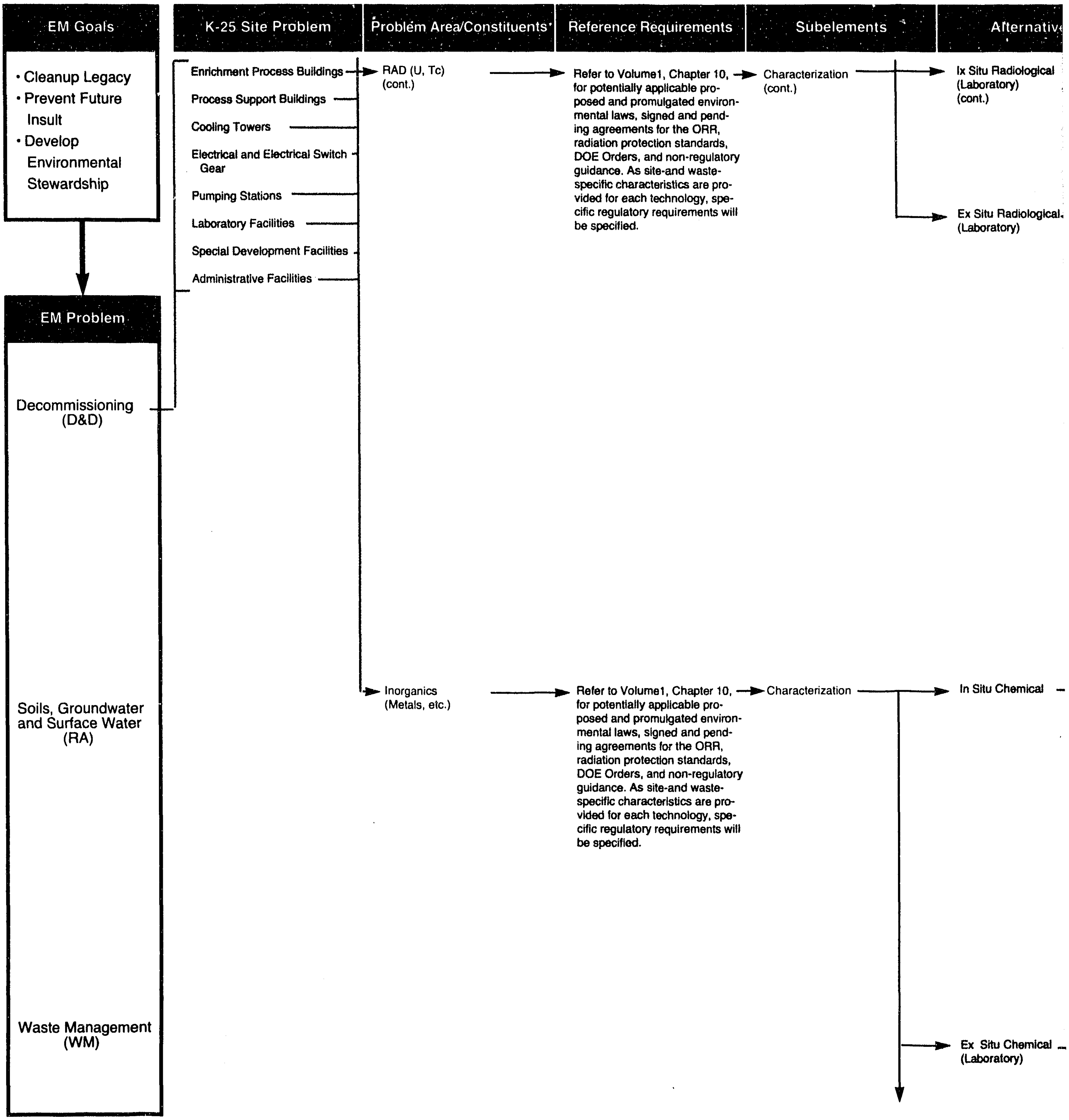
EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Ex Situ Chemical (Laboratory) (cont.)	Ion Chromatography (IC) CHAR-50-OG	**Accept** Able to quickly and accurately determine anions or cations in solution to ppm or ppb concentration. Accepted by EPA and industry.	Development - Selection and set up of most appropriate system for site-specific needs.	Instruments available. **Development Costs:** @$200K
In Situ Radiological	Measurement Of Natural Gamma Emitters CHAR-51-OG	**Demonstration** - The ability to obtain an accurate measure of gamma emitters for determination of background levels and to monitor small changes in concentration is very important.	Mature technology. Adapt existing equipment, calibrate, optimize procedures and write protocols to obtain in-situ measurements.	Development costs $300K
	Passive Neutron CHAR-104-OG	**Accepted** - Useful for all matrices for U determination. F must be present. Should be calibrated with similar matrix material. Currently used to measure uranium holdup.	Calibration models for expected D&D scenarios.	<$25 measurement
	TLD Array for a Spatial Characterization CHAR-103-OG	**Demonstration** Reusable detector sheet contains 1000 pixels; detection limit is 20 alpha rays/pixel; maps contamination fields.	Commercially available instrumentation needs adaptation for field use.	Ready for pilot testing. Laser reader $60K, reusable detector sheet $225; Development costs $100K.
	NaI Gamma Spectroscopy √ CHAR-106-OG CHAR-112-OG	**Accepted** Useful for U235 and U238 detection. Can measure subsurface activity. Technology and instrumentation available.	Correction factors methodology needs to be published.	High resolution Ge detector may be needed to determine correction factors for absorption. Combination NaI and Ge detectors $40K; development cost $250K. Measurement cost <$25.
	Proportional Counting √ CHAR-108-OG	Accepted - Sensitive to 100dpm/cm2. Probes can be made large for wide areas, or small to fit into process piping. May be able to distinguish between U and Tc.	Development work to distinguish between U and Tc. Modification for vertical, overhead or specific Site geometries.	Development cost $50K.
	Small Long-Range Alpha Detection (LRAD) Δ CHAR-65-OG	**Demonstration** - Actively detects surfaces/objects contaminated at or below release limits; measures ionized air drawn from containment regardless of shape of article. Potential on-line measurement. Demonstrated at Fernald.	Adaptation for Site-specific applications, optimization of methods, and development of procedures and protocols.	Normal implementation costs. @$2-3K for equipment, Operating Costs @ $20/sample **Development Costs:** @$100K
	"Electret" Passive Surface Alpha Detection Δ CHAR-95-OG	**Demonstration** - Sensitive (100minute exposure for quantification), inexpensive devices can be used in large numbers; particularly useful for cleanup verification. Commercialized for Radon monitoring; easily adapted for surface alpha contamination. Potential for niche applications.	Needs equipment adaptation, evaluation and validation for niche applications. Definition of limitations in mixed radiation fields.	Development cost $200K.
	In-Situ Passive Monitors For surface Contamination By Weak Beta Radionuclides √ Δ CHAR-102-OG	**Pre-demonstration.** - Reuseable TLD-like chip small size detectors for monitoring Tc in difficult-to-access locations. Detectors can be deployed in large numbers.	Thorough evaluation for use in mixed surface contamination areas. Testing and evaluation of ceramic exoelectron materials to select most suitable type for Site-specific applications.	Commercial exoelectron reader in hand; materials testing development work $300K. <$25 per detector.

Technology Logic

Characterization



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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Ix Situ Radiological (Laboratory) (cont.)	Alpha Track Etch Detection CHAR-96-OG	**Demonstration** High sensitivity (100min for quantification at 220 dpm/100cm2. Small size; deployable on irregular and difficult to access areas; can be used in large numbers. Provides permanent record for cleanup. Fully commercialized for radon detection and monitoring.	Needs verification for surface characterization; adaptation to Site-specific applications.	Small coupons cost <$5. Deployment in large numbers will require establishment of on-Site chemical etching and track reading capabilities.
Ex Situ Radiological (Laboratory)	Waste Curie Monitoring (Semi-Lab) Δ CHAR-109-OG	**Accepted** Good for measuring scrap lumber for low levels of radioactivity. Must be used in conjunction with a high resolution gamma spectrosopy sytem to determine atomic abundance.	None. "Off-the-shelf" designs handle 55-gallon drums. Larger systems if needed could be developed.	In current use.
	Neutron Activation (Semi-Lab) Δ CHAR-107-OG	**Accepted.** (DOT) Currently used or the determination of U; specific for U235; useful in almost any matrix. Equipment is expensive.	Development needed for containers larger than 55- gallon drums. Separate calibration standards are needed for each matrix.	Equipment is expensive (.5-1.5M)
	Select Alpha Radionuclide Analysis By PERALS Δ (Semi-Lab) CHAR-97-OG	**Accepted** Most sensitive alpha-selective analytical method available (1 pCi/gm). Ideal for U analysis. Commercially available reader and scintillant cocktails.	Adaptation for Tc (β) and other radionuclides.	Laboratory set up at ORNL DOSAR facility. Could be adapted for rapid monitoring of both airborne and loose contamination ($20K). Development cost for Tc $250K.
	Liquid Scintillation Counting CHAR-129-OG	**Accepted** Mature technology in current use.	None. "Off-the-shelf"	In current use.
In Situ Chemical	X-Ray Fluorescence √ CHAR-6-OG CHAR-98-OG	**Accepted** Accepted by the EPA for Level 1 site assessment.	Downsizing for robotics applications	Development cost 100K. Capital equipment costs 5K-10K.
	Ultra-Violet/Visible (UV-Vis) Spectroscopy CHAR-9-OG	**Accepted** This mature technology can be used in a variety of field and laboratory procedure for the identification of materials. It can provide rapid screening capabilities for sample selection.	Model studies and application design	**Hardware Costs:** <$200K **Development Costs:** <$100K
	Laser-Ablation Inductively Coupled Plasma Atomic Emission Spectroscopy CHAR-111-OG	**Demonstration** No waste. Robotics and automation potential. Demonstrated at Fernald.	Need to tailor to site-specific conditions and validate. Need to increase ablation and portability. (Ames Laboratory)	**Development:** $500K **Equipment:** $500K
Ex Situ Chemical (Laboratory)	Atomic Absorption Spectroscopy (AA, AE) CHAR-76-OG	**Accepted** In widespread routine use. Accepted by EPA.	General lab (see text)	Technology available. **Operating Cost:** $25-50 per analysis

Technology Lo

Characteriz

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

K-25 Site Problem

- Enrichment Process Buildings
- Process Support Buildings
- Cooling Towers
- Electrical and Electrical Switch Gear
- Pumping Stations
- Laboratory Facilities
- Special Development Facilities
- Administrative Facilities

Inorganics (Metals, etc.) (cont.) → Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified. → Characterization → Ex Situ (Labora (cont.)

Organics (including VOCs, PCBs) → Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified. → Characterization → Samplin; In Situ ((Labora

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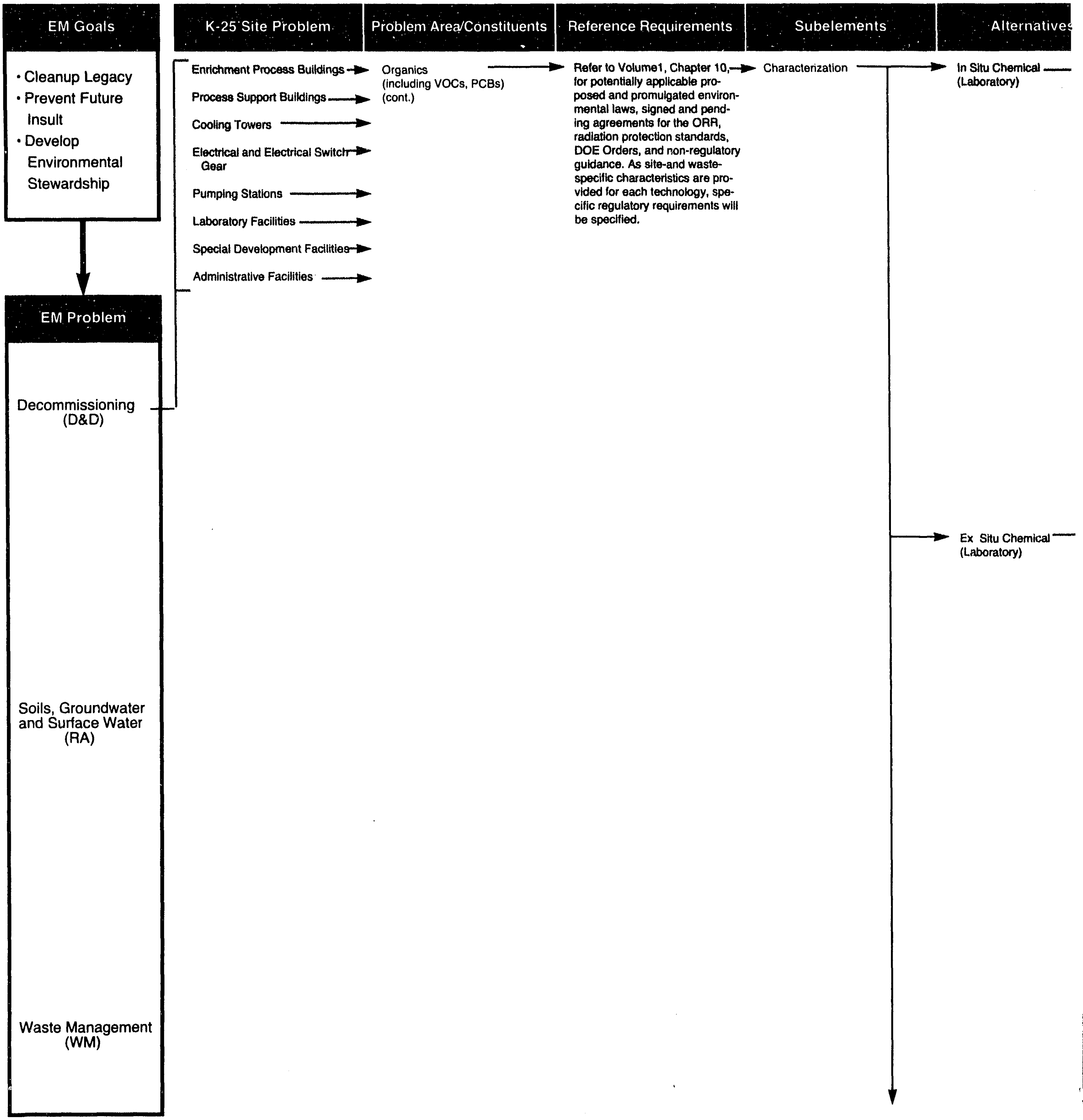
Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Ex Situ Chemical (Laboratory) (cont.)	Inductively-Coupled Plasma Spectroscopy (ICP) CHAR-77-OG	Accepted - Multi-element technology in widespread routine use.	General lab (see text)	Technology available. **Operating Cost:** $100-$150 per sample.
	Inductively Coupled Plasma - Mass Spectrometry (ICP-MS) CHAR-78-OG	Accepted - Multi-element technology more selective than ICP-AES. Isotopic analysis. Accepted by EPA.	Development in progress to combine with laser ablation for surface analysis.	Technology available. **Operating Cost:** $100-$200 per multi-element analysis.
	Particle-Induced X-Ray Emission (PIXE) CHAR-17-OG	Accepted - Mature technology provides trace elemental analysis with micro and mapping capabilities. Accepted by industry.	General lab (see text)	Technology available at outside labs. Cost ea. $50 or more per sample.
	Cold Vapor (Mercury) CHAR-24-OG	Accepted - In widespread routine use for Hg. Accepted by EPA.	General lab (see text)	None. Technology available.
	Extended X-Ray Absorption Fine Structure (EXAFS) CHAR-30-OG	Accepted - Determine bonding structure and nearest-neighbor interactions for non-crystalline materials. Accepted by industry,	Development - Need study of site-specific model samples to undusted interactions for specific elements/matrix combinations of interest.	Have access to instrument at BNL-NSLS. Software and personnel exist for interpretation of results. **Development Costs:** @$200K
	Energy-Dispersive X-ray Spectroscopy (EDS, EDX, EDAX) CHAR-35-OG	Accepted - Mature technology. (≥Be) Rapid elemental or analysis (quantitative for solids) in conjunction with electron microscopy. Can qualify small localized areas or inclusions on bulk materials. Accepted by industry. Widely used.	Development of procedures, quantitative models and database for site-specific scenarios..	<$100/sample **Development:** $200K
	Wavelength Dispersive X-Ray Spectroscopy (WDS, WDX, Electron Microprobe) CHAR-66-OG	Accepted - Mature technology. rapid elemental analysis (≥Be) of solid samples, in conjunction with electron microscopy. Can quantify small localized areas or inclusions in bulk materials. Widely used, accepted by industry.	Development of procedures, quantitative models and database for site-specific scenarios..	<$100/sample **Development:** $200K
	Mossbauer Spectroscopy CHAR-47-OG	**Accepted** Ultra-high resolution spectroscopy; limited to isotope pairs with overlapping excitation lines. The use of synchrotron radiation is growing as a means to broaden this technique.	Mature technology. Database and model approach development.	**Instrument Costs:** $75-$200K **Operating Costs:** $200K
Sampling, Sample Prep	Solid Sorbent Sampling CHAR-91-OG	**Demonstration** Allows collection & concentration of vapors.	Methods development for specific applications.	**Development Costs:** $50K
In Situ Chemical (Laboratory)	Organic Vapor Monitoring √ CHAR-5-OG	**Accept** Used routinely in IH monitoring of workplace atmospheres in relations. Accepted by OSHA, industry.	Development - Need to calibrate responses to any unique air contaminants expected at the site.	Normal implementation needs. **Instrument Costs:** $3 to $6K each **Operating Costs:** Few $ per test.
	Gas Chromatography (GID, IC, TC) √ CHAR-100-OG	**Accepted** Used routinely for more detailed analysis of workplace atmospheres in near-real-time. Accepted by OSHA, EPA, industry.	Need to develop specialized procedures for rapid identification of suspect materials.	**Instrument Costs:** $7 to $30K each **Development Costs:** $25-$100K
	Differential Ultraviolet Absorption Spectroscopy (DUVAS) CHAR-130-OG	**Demonstration** Prototype instrument produced reliable data at ORNL, with small aromatics.	Ned to extend capability range to other contaminants and streamline prototype.	**Capital Costs:** $200K **Development Costs:** $200K

Technology Logic
Characterization



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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
In Situ Chemical (Laboratory)	Fourier Transform Infra-Red Spectroscopy (FTIR) CHAR-8-OG	**Accepted** A multitude of detector and sampling devices exist to allow gas, liquid, solid, and micro analysis to be performed. This is a very mature technique with a host of applications to any ERWM pro-program.	Database for rapid materials identification and model studies of materials interaction.	**Hardware Costs:** $25K to $500K **Development Costs:** <$200K
	Long-Path FTIR CHAR-18-OG	**Pre-Demonstration** - Capable of monitoring large areas, real-time measurements, remote sensing. Vendor units available.	Development - Need to develop software to enhance site-specific application.	Moderate capital and software development costs.
	SAW Sensors CHAR-14-OG	**Development/demonstration** Fast response time direct measurement of organic vapors; when coupled with desorption (see sampling) applicable for surface contamination. Detection limits of ppm possible; can be tailored to a specific gas or family of gases. Particularly suitable for robotic applications. Development of PCB sensors under way on-Site.	Coatings to allow detection of specific gases. Desorption devices need to be optimized for surface characterization. Extension to on-line process monitoring.	Development $300K. Device cost $10K.
	Immunoassay (PCB) CHAR-23-OG CHAR-99-OG	**Demonstrated** DOE/LMDField Methods Project has demonstrated 1ppm sensitivity in soils. Commercially available test kits.	Development - Need for slight adaptation of method for samples other than soils.	Normal development and implementation costs. **Capital Costs:** $100-$200 **Development Costs:** $200K
Ex Situ Chemical (Laboratory)	Synchronous Fluorescence (PAH) √ CHAR-101-OG	**Demonstrated** Method currently being implemented at Y-12 for PAH in groundwater.	Development - Methods needs validation for various matrices in order to be accepted by EPA.	Normal implementation costs. **Capital Costs:** $25K **Development Costs:** $100K
	Gas Chromatography - Mass Spectroscopy (GC-MS) CHAR-88-OG	**Accepted** EPA approved technique for organic compound identification can provide rapid identification.	Improved sampling protocols for rapid turn around analysis. Protocols for automated instrumentation.	**Capital Costs:** $300K **Development Costs:** $100K
	Gas Chromatography - Fourier Transform Infrared Spectroscopy (GC-FTIR) CHAR-66-OG	**Demonstration** Technology demonstrated to supplement GC-MS for compound identification. GC-FTIR located at Y-12 and X-10. Not yet EPA approved.	Development - Need to develop protocols for targeted analysis and evaluate optimum commercial software for site-specific applications.	**Capital Equipment:** $200K **Development Costs:** $300K
	Liquid Chromatography - Mass Spectrometry (LC-MS) CHAR-89-OG	**Demonstration** Technology demonstrated to provide unambiguous identification and quantitative measurement of compounds not amenable to GC-MS. Not yet EPA-approved.	Development - Need to develop and validate protocols for targeted analytes.	**Capital Equipment:** $200K **Development Costs:** $300K
	Glow Discharge Ionization Mass Spectroscopy CHAR-56-OG	**Accepted** On site monitoring of organic compounds in a variety of host matrices with quantitation down to the ppb level. Rugged and portable.	Instrumental development. Model studies of host interactions and interferences for quantitative analysis.	**Capital Equipment:** $500K **Development Costs:** $200K
	Differential Optical Absorption Spectroscopy Δ CHAR-27-OG	**Accepted** Best suited for long UV absorbers; fast response time, stable spectral emission, ppm to ppb detection levels.	Model studios and quantitative calibration curves for specific monitoring scenarios.	**Capital Equipment:** $200K

Technology Lo

Characteriz

EM Goals

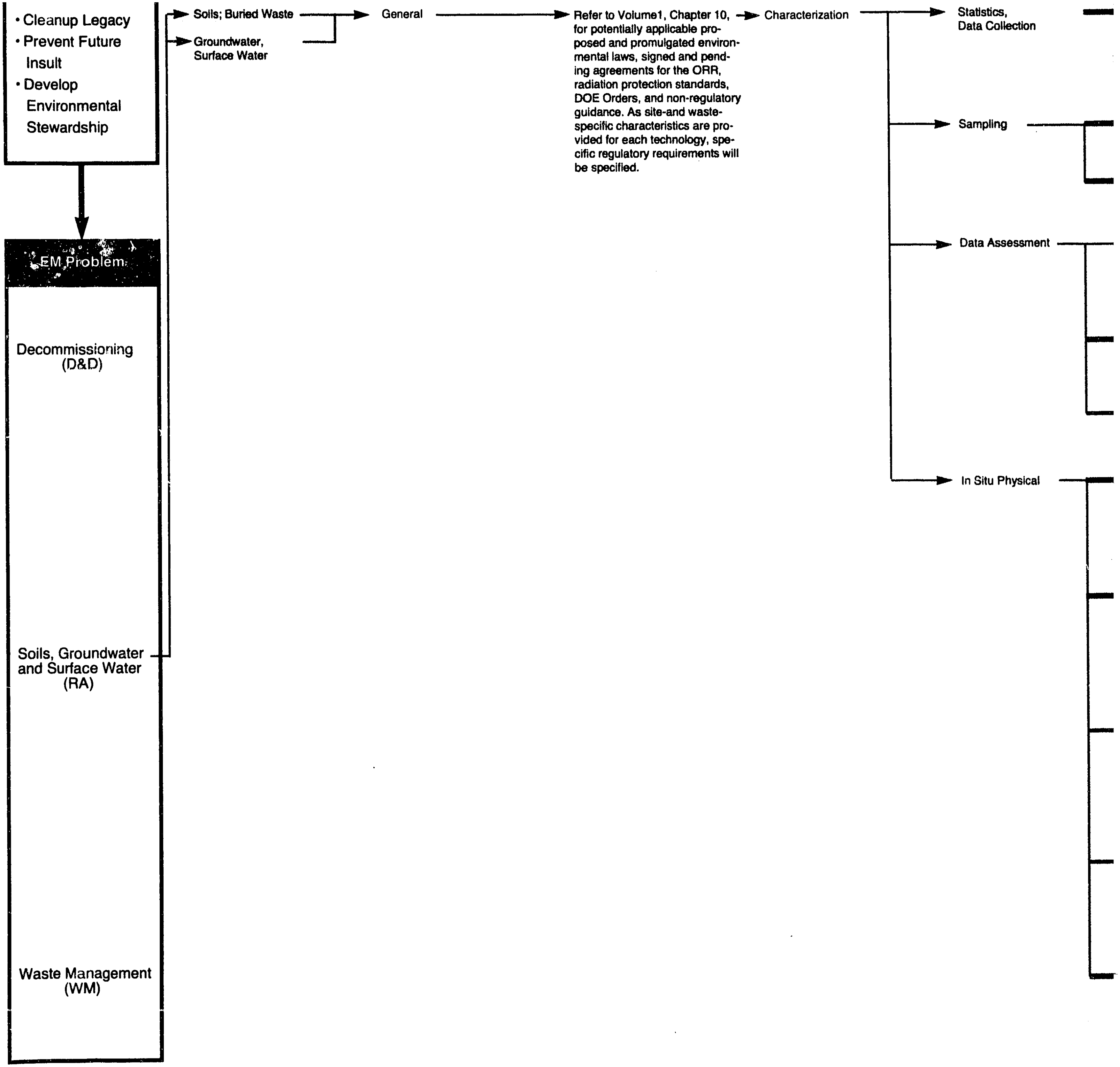
- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
Enrichment Process Buildings Process Support Buildings Cooling Towers Electrical and Electrical Switch Gear Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities	Organics (including VOCs, PCBs) (cont.)	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Characterization	Ex Sit (Labor (cont.)
Enrichment Process Buildings	General	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Characterization	Physic In Situ Data A
	Radioactive Elements	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Characterization	In Situ
Enrichment Process Equipment	General	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Characterization	Physic In Situ Data Ac
	Materials. Classification Issues.		Characterization	

Ex Situ Chemical (Laboratory) (cont.)	Direct Sampling Ion Trap Mass Spectrometry (DSITMS) CHAR-90-OG	**Demonstration** Allows rapid determination of organics in air and possibly on surfaces.	Methods development and field testing.	**Hardware Costs:** $100K **Development Costs:** $100K
	On-line Supercritical Fluid Extraction- Multidetector Gas Chromatography (SFE-GC) CHAR-115-OG	**Pre-demonstration.** One commercial unit available for total petroleum hydrocarbons in soil. Could cut analysis cost by factor of 4, reduce solvent - contaminated waste, and improve sample turnaround time. Could be expanded to PCBs and other solids.	Optimization for PCBs and hydrocarbons in a single operation, validation and protocol development.	**Instrumentation Cost:** $60K **Operating Costs:** < $500/sample **Development Cost:** $250K
Physical In Situ	NDT For Concrete CHAR-38-OG	**Accepted** - In-site tests for physical properties without causing damage to existing structure. Accepted by industry.	Development - Need to develop testing protocols for characterizing and evaluating large concrete structures.	Development of testing plan for site buildings. Field testing equipment $100K.
Data Assessment	Inorganic Matrix-Contaminant Composite Modeling CHAR-39-OG	**Pre-Demonstration** - Approach for developing understanding of cement-like materials and their interactions with other materials.	Development - Need to characterize the variations in cement for the various site-specific structures and their matrix/contaminant interactions. Beneficial interaction with BNL.	**Development Costs:** ~ $500K
In Situ	NaI Floor Scanner √ CHAR-105-OG	**Pre-demonstration** Not as sensitive as alpha/beta detection; good for detection of sub-surface radioactivity.	Adaptation of existing instrumentation for field use.	<$25 measurement. $100K development cost.
Physical In Situ	Radiographic Imaging CHAR-40-OG	**Accepted** Digital radiography can be used to determine location and distribution of deposits within cascade systems, as well as determine the status of process systems and equipment.	Need to optimize collection parameters for specific site applications, and adapt image enhancement techniques for radiographic applications.	Field and laboratory systems for specific materials and geometries. **Equipment Cost:** $200K, **Development Cost:** $100K.
	Conventional Leak Detection Methods CHAR-68-OG	**Accepted**	Well Accepted, Needs Tailoring for Specific Applications	Inexpensive. Equipment Exists in Plant
	Acoustic Emission CHAR-69-OG	**Commercial** Accepted/Development for Deposit	Tailoring for Specific Applications. Some Development for Deposit Location	Vacuum or Pressure Capability
	Ultrasonic Leak Detection Δ CHAR-70-OG	**Demonstration** Available low cost technology which maybe useful to rapidly test for leaks in secondary containment structures such as glove bags as well as process systems.	Technology available.	Ready to go. Equipment on site
Data Assessment	Criticality Indices CHAR-44-OG	**Accepted** The need to quickly identify components that are not critically safe.	Need to develop rapid-response software for evaluation of materials, instrumentation, tools to be used in high assay D&D.	**Development Costs:** $100K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Soils; Buried Waste
Groundwater, Surface Water
General
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Characterization
Statistics, Data Collection
Sampling
Data Assessment
In Situ Physical

Logic Diagram
cterization

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Statistics, Data Collection	Ultrasonic Ranging and Data System (USRADS) CHAR-123-OG	**Demonstrated** This technique tracks surveyor position and automatically associates position with electronically transmitted data. Measurement density provides high resolution distribution data. Hasbeen used at K-25 Site.	Currently being commercially interfaced to measurement systems.	**System Cost:** ~ $30K
Sampling	Punch Cores CHAR-83-OG	**Demonstration** (ARID Site ID)	Commercial Instrumentation Available	**Development Cost:** $100K
	Wells & Punch Sources CHAR-82-OG	**Accepted** EPA	Evaluation of the Role of Pump Rate & Time	none
Data Assessment	Subsurface Complexation CHAR-45-OG	**Demonstration** Technology allows modeling of contaminant host interactions to enhance understanding of environmental transport	Development - Need to develop models for site - specific contaminants and host matrices.	**Development Costs:** $100K
	Tc Geochemical Behavioral Modeling CHAR-49-OG	**Demonstration**	Develop models to determine the nature of Tc with concrete, soil, & groundwater.	**Development Costs:** $400K
	Biocompatibility Studies CHAR-114-OG	**Demonstration** To assess long-term effect of clean-up work.	Development and validation of model systems.	**Development Costs:** $200K
In Situ Physical	Ground–Penetrating Radar CHAR-124-OG	**Accepted** Extremely short electromagnetic pulse return interference by both metallic and non-metallic objects. Useful in locating buried objects.	Improvements in depth of penetration, signal-to-noise and signal processing, particularly antenna design. Could be developed to measure subsurface plumes.	Antenna **Development Cost:** ~$400K **Systems Cost:** $100K Commercial Rental equiptment is available.
	Electrical and Electromagnetic (EM) Methods CHAR-125-OG	**Developed thru Accepted** Useful for mapping site subsurface features which influence containment transport and which might be missed through drilling. Used airborne (Oak Ridge) and on the surface. Could be used in borehole applications and might be developed for actual plume detection.	Development of site-specific techniques, and data handling and imaging methods. LLNL developed borehole system could be adapted for use in Oak Ridge.	**Development Cost:** $200K **System Cost:** $100K Commercial rental equipment is available.
	Seismic Methods (Refraction, Profiling, Reflection) CHAR-126-OG	**Developed thru Accepted** Refraction and deep reflection have been used successfully for years; however shallow (<30m) reflection capability is relatively recent. Useful for identification and mapping of geological features which control contaminate migration	Developed shallow sources should be tested. Techniques should be adapted and used for both vertical and horizontal boreholes.	**Development Cost:** $200K **System Cost:** $50K Commercial rental equipment is available.
	Microgravity Methods CHAR-127-OG	**Development** Gravity methods have been sucessfully used in mining and petroleum industries. Increased sensitivity is needed for accurate, unambiguous interpretation (microgravity). Microgravity has been used at the K-25 Site.	Development of incresed sensitivity for rapid, cost-effective subsurface detection and mapping. Site-specific development for detection of karst cavities and conduits.	**Development Cost:** $200K **System Cost:** $60K Commercial rental equipment is available.
	Magnetics CHAR-128-OG	**Accepted** Useful for detecting buried ferrous metal objects. Aerial survey completed in Oak Ridge.	Development of methods to minimize interference.	**Development Cost:** $200K **System Cost:** $15K Commercial rental equipment is available.

Decontaminat

The Decontamination section addresses concepts and approaches for removing va the large number of combinations of contaminants and substrates, some simplificatior accomplished by dividing problem areas into ten different groups that had common tre transite, asbestos pipe insulation, and Munter's Fill; porous nickel and aluminum; freo sheet metal, metal equipment (exterior), and copper; nickel-lined steel (interior), steel, cylinders (materials used on the interior of process equipment, pipes, etc. and such ite

tamination

; for removing various contaminants from facilities and equipment. Because of ne simplification was necessary to limit the size of the diagram. This was had common treatment technologies: insulated copper wires and instruments; aluminum; freon; plastic; tile, wood, gasket material, and composite roofing; (interior), steel, Monel, copper, aluminum, steel pipe, aluminum pipe, and steel etc. and such items that contained UF_6 gas); deposit recovery; and concrete.

Technology Logic

Decontamination

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

Enrichment Process Building

Process Support Building

Electrical and Electrical Switch Gear

Pumping Stations

Laboratory Facilities

Special Development Facilities

Administrative Facilities

Cooling Towers

Problem Area/Constituents

Ni-Lined Steel
Equipment **Interior**
U, Tc, Actinides

Steel
Chromate

Monel
U, Tc, Actinides

Copper
U, Tc, Actinides

Aluminum
U, Tc, Actinides, S, Cr

Steel Pipe
As, Chromates, Ba, Dioxins

Aluminum Pipe
U, S, Cr

Steel Cylinders
UF_6, Tc, Actinides

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelements

Decontamination

Alternative

Mechanical Substra
Surface Removal
(fixed and transferr
contamination)

Mechanical Substrate Surface Removal (fixed and transferrable contamination)	Ultrahigh-Pressure Water (up to 50,000 psi) DCON-35-OG	**Accepted** Technology is used by industry to decontaminate metal parts. Should work for listed contaminants and substrates. Unless a recycle system is developed, waste would be 3-5 gal water per ft^2 cleaned containing contaminants removed plus, perhaps, some metal substrate.	Development - To minimize waste generation, a system is needed to treat the water so that it can be recycled. Improvement - Vacuum systems with nozzles designed to match commonly decontaminated parts are needed to minimize the spread of contamination.	Prior removal and disassembly of contaminated equipment plus an enclosed glove box and/or room that is easily decontaminated on the inside is needed in which the ultra high-pressure water (UHPW) system will be used. Development cost: $1.3M (Recycle system); $200-1000K (Vacuum system for each nozzle design) Capital cost: UHPW system: > $500K (with vacuum system) Glove box: <$50K Work room: About $250K Operating cost: >$2/ft^2
	Shot Blasting DCON-36-OG	**Accepted** Commercial shot blasters are used to remove rust and marine growth from ship hulls and to clean structural steel. Decontamination factors of 10-100 can be expected. Waste is about 0.1 lb spent shot/ft^2 decontaminated plus contaminants removed and trace amounts of eroded substrate.	Improvement - Vacuum systems with nozzles designed to match commonly decontaminated parts are needed to minimize the spread of shot and contamination.	Prior removal and disassembly of contaminated equipment plus an enclosed glove box and/or room that is easily decontaminated on the inside is needed in which the shot blaster system will be used. Development cost: $200-1000K (Vacuum system for each nozzle design) Capital cost: Shot blaster: > $50K (with vacuum system) Glove box: <$50K Work room: About $250K Operating cost: About $0.40/$ft^2$
	Grit Blasting DCON-38-OG	**Accepted** Has been used for many applications in the nuclear industry. Technology is generally effective (DF=10-100). Waste would be spent grit containing abraded substrate and removed contaminants plus filter. Waste production rates depend upon substrate being decontaminated (0.005-0.1 lb/ft^2)	Improvement - 1) More durable blast media are needed to minimize wastes. 2) Better vacuum systems for collecting blast media are needed to minimize spread of blast media and contamination. 3) Demonstration of specific blast media for listed contaminants and substrates is needed. 4) Process automation is needed to improve efficiency. 5) A system to separate contaminants from blast media and package the wastes is needed.	Prior removal and disassembly of contaminated equipment plus a system to separate contaminants from blast media and package the wastes is needed. Development costs: 1) More durable blast media, 2) Better vacuum systems, 3) demonstration on listed contaminants and media: $1-6M, 4) Process automation: $3-4M, 5) Waste treatment and packaging: About $4M Capital cost: About $500K Operating cost: >$2/ft^2

Technology Log

Decontamin

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Al
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Building Process Support Building Electrical and Electrical Switch Gear Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Cooling Towers	Ni-Lined Steel Equipment **Interior** U, Tc, Actinides Steel Chromate Monel U, Tc, Actinides Copper U, Tc, Actinides Aluminum U, Tc, Actinides, S, Cr Steel Pipe As, Chromates, Ba, Dioxins Aluminum Pipe U, S, Cr Steel Cylinders UF_6, Tc, Actinides	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Mecha Surfac (fixed a contam (cont'd)

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

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Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Mechanical Substrate Surface Removal (fixed and transferrable contamination) (cont'd)	Centrifuge Cryogenic CO_2 Pellet Blasting DCON-39-OG	**Predemonstration** Centrifuge pellet acceleration has been demonstrated in the DOE fusion energy program. Technology will be likely successful with essentially infinite decontamination factors. Waste would be filters and HEPA filters filled with removed contamination and a small amount of substrate, which would also be removed.	Development - Demonstration of a practical system with high-velocity pellets delivered at a sufficient rate and adequate collection of removed contaminants.	Prior removal and disassembly of contaminated equipment and a glove box or room that is easily decontaminated in which the decontamination will be accomplished plus oxygen depletion precautions are needed to use this technology. Development cost: <$3.4M Capital cost: Centrifuge CO_2 system: About $200K Glove box: <$50K Work room: About $250K Operating cost: About $0.25-$0.75/ft^2
	Ice Blasting DCON-40-OG	**Accepted by Industry** Efficacy of commercial system for this application needs demonstration at K-25. Waste would be about 14 to 18 gallons/hour waste water containing removed contaminants.	Development - automation/robotics.	Prior removal and disassembly of contaminated equipment and a glove box or room that is easily decontaminated in which the decontamination will be accomplished are needed to use this technology. Capital cost: Evaporator for wastewater treatment: ~$60K. Ice blasting system: About $180K (Add about $240K for automatic control) Glove box: <$50K Work room: About $250K Operating cost: < $1/ft^2
	Supercritical CO_2 Blasting DCON-41-OG	**Predemonstration** This technology is being developed by a private company. Likely to be effective with large decontamination factors. Waste would be contaminants and a small amount of the substrate contained in a cyclone and HEPA filters.	Development - Investigate the effect of operating parameters on removal rates and removal and collection efficiencies for contaminants. Demonstrate efficacy for substrates and contaminants of interest.	Prior removal and disassembly of contaminated equipment and a glove box or room that is easily decontaminated in which the decontamination will be accomplished plus oxygen depletion precautions are needed to use this technology. Development cost: $250K-$1000K Capital cost: Supercritical CO_2 system: $500-$1000K Glove box: <$50K Work room: About $250K Operating cost: > $2/ft^2

Technology Logic

Decontamination

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

Enrichment Process Building

Process Support Building

Electrical and Electrical Switch Gear

Pumping Stations

Laboratory Facilities

Special Development Facilities

Administrative Facilities

Cooling Towers

Problem Area/Constituents

Ni-Lined Steel
Equipment **Interior**
U, Tc, Actinides

Steel
Chromate

Monel
U, Tc, Actinides

Copper
U, Tc, Actinides

Aluminum
U, Tc, Actinides, S, Cr

Steel Pipe
As, Chromates, Ba, Dioxins

Aluminum Pipe
U, S, Cr

Steel Cylinders
UF_6, Tc, Actinides

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelements

Decontamination

Alternatives

Mechanical Substrate Surface Removal (fixed and transferrable contamination) (cont'd)

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amination

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Mechanical Substrate Surface Removal (fixed and transferrable contamination) (cont'd)	Plastic Pellet Blasting DCON-42-OG	**Accepted** Plastic pellet blasting is a widely used alternate to sand blasting for applications in which it is desired to impart minimal damage to the substrate. Technology is not likely to remove listed contaminants from listed substrates. Waste would be spent plastic pellets plus any removed contamination.	Improvement - Minimize blast media erosion to minimize waste; automation/robotics.	Prior removal and disassembly of contaminated equipment and a glove box or room that is easily decontaminated in which the decontamination will be accomplished plus a system for processing wastes to an acceptable form are needed to use this technology. Development cost: $250K-$1000K Capital cost: Plastic pellet blasting system: About $50K Glove box: <$50K Work room: About $250K Operating cost: $0.75-$2.25/ft²
	Grinding, Honing, Scraping DCON-43&44-OG	**Accepted** Hand grinding has been used successfully for small-scale decontamination at K-25. Technology is successful. Waste is removed substrate plus contaminants.	Improvement - A remotely operated system for minimizing worker exposure should be developed.	Prior removal and disassembly of contaminated equipment and a glove box or room that is easily decontaminated in which the decontamination will be accomplished plus a system for processing wastes to an acceptable form are needed to use this technology. Development cost: $250K-$1000K Capital cost: Grinder: $150 ($75K-$200K with remote operation) Glove box: <$50K Work room: About $250K Operating cost: about $1/ft²
	Metal Milling DCON-45-OG	**Accepted** Milling has been used to decontaminate individual items at K-25. Milling will remove any contamination completely along with part of the substrate. Waste will be the top layer (up to 1/8 in.) of substrate containing the contaminants.	None	Prior removal and disassembly of contaminated equipment is needed to use this technology. Capital cost: About $150K Operating cost: About $17.50/ft²

Technology Lo

Decontamin

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

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Process Support Building

Electrical and Electrical Switch Gear

Pumping Stations

Laboratory Facilities

Special Development Facilities

Administrative Facilities

Cooling Towers

Problem Area/Constituents

Ni-Lined Steel
Equipment **Interior**
U, Tc, Actinides

Steel
Chromate

Monel
U, Tc, Actinides

Copper
U, Tc, Actinides

Aluminum
U, Tc, Actinides, S, Cr

Steel Pipe
As, Chromates, Ba, Dioxins

Aluminum Pipe
U, S, Cr

Steel Cylinders
UF_6, Tc, Actinides

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

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Decontamination

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Logic Diagram
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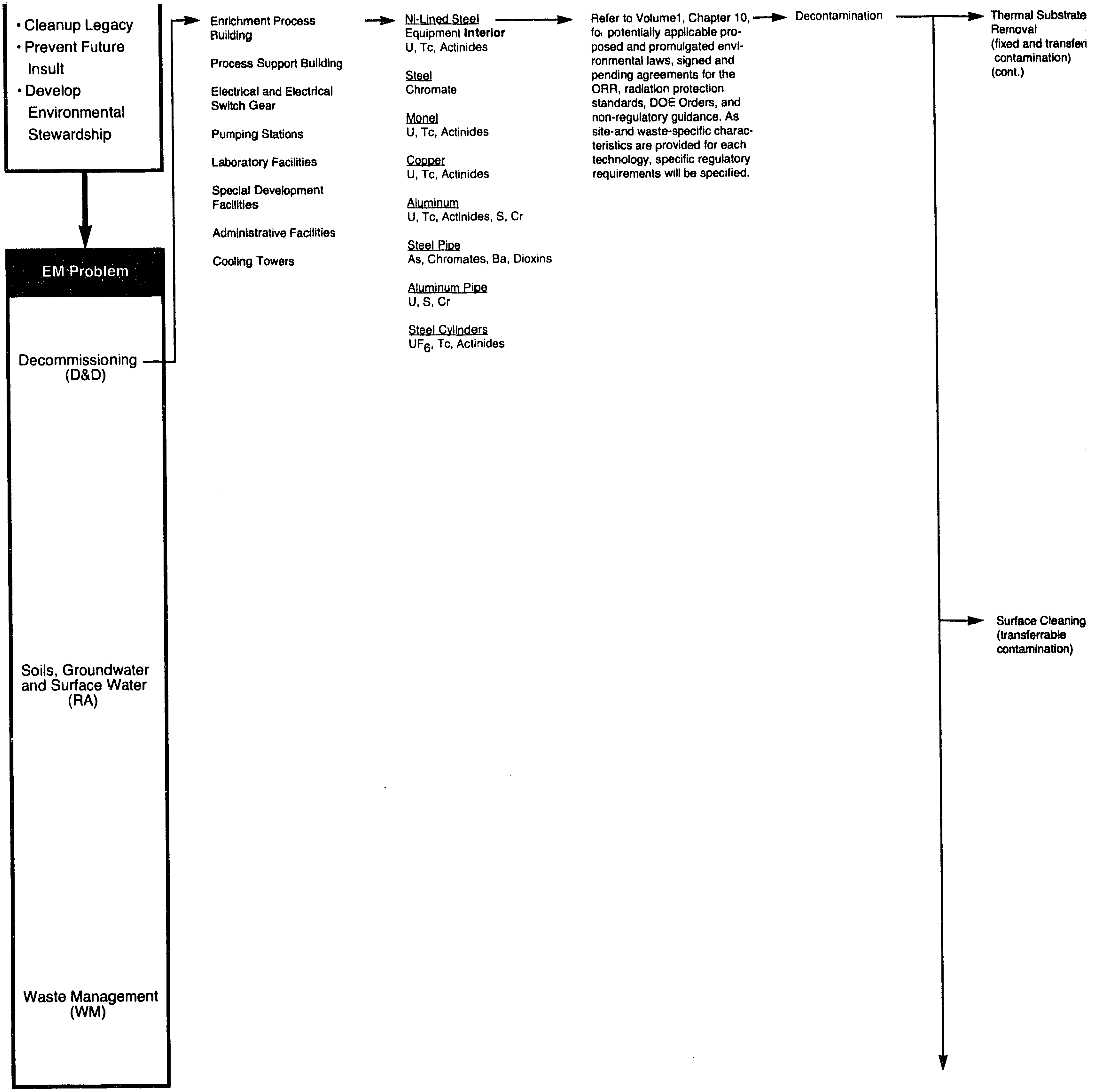
Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Thermal Substrate Surface Removal (fixed and transferrable contamination)	Plasma Torch DCON-72-OG	**Evolving Technology** Conceptual - Plasma torches exist commercially to weld and cut materials that either have a very high melting temperature or require an inert atmosphere to prevent oxidation. Plasma torches have not been used to decontaminate metal but can be expected to do so effectively by melting or vaporizing the surface layer, including the contaminants. Waste would be vaporized or melted metal containing removed contaminants.	Development - The efficacy of a plasma torch in removing various organic and inorganic contaminants must be demonstrated on a bench scale. A method for collecting the removed substrate and contaminants is needed. Improvements - Plasma torch cleaning should be adapted to robotic and automatic operation.	Prior removal and disassembly of contaminated equipment and a collection system with an adequate filter system is needed to use this technology. An electric power supply would be needed. Development cost: About $3M Capital cost: About $200K Operating cost: <$2/ft^2
	Laser Heating DCON-73-OG	**Pre-demonstration** Ames Laboratory has demonstrated decontamination of metals by surface removal on a bench scale. Technology should be effective for the listed contaminants. The waste would be filters and HEPA filters containing the removed substrate and contaminants.	Development - Existing laser based photothermal methods should be demonstrated on a larger scale. Lasers with different operating parameters should be tested on a bench scale to evaluate whether more efficient laser systems exist.	Prior removal and disassembly of contaminated equipment, a glove box or a room in which the contamination can be accomplished, and a collection system with an adequate filter system is needed to use this technology. Development cost: Over $2M Capital cost: $500K-$1000K Operating cost: About $1/ft^2
	Plasma Etching/Fluorination DCON-76-OG	**Pre-demonstration** Plasma surface cleaning by glow discharges is commonly and effectively utilized for cleaning high bonding energy contaminants from surfaces of metals prior to the operation of fusion devices. Technology is expected to be effective for listed contaminants on listed substrates, but whether the plasma can follow the irregular shapes involved (compressors, etc.) is uncertain. Wastes would be the vaporized contaminants and substrates on prefilters and HEPA filters.	Science - Data on cleaning rates for contaminants and substrates of interest are needed. Development - The capability of plasma generation and cleaning on complex internal surfaces of contaminated equipment with large surface areas needs to be established.	Normal implementation needs and a collection system with an adequate filter system. Development cost: About $10M Capital cost: about $2M Operating cost: $0.01-$0.30/ft^2
	Laser Etching and Ablation DCON-74-OG	**Pre-demonstration** (evolving technology) - The conceptual basis for this technology exists, and a similar technique is used to clean optical surfaces and microelectronics. Technique is likely to be successful. Wastes would be removed deposit, traces of removed substrate, and filters and HEPA filters from the filtration system.	Development - Existing lasers, optics, and vacuum and filtration systems need integration into a system; then, this system should be demonstrated.	Prior removal and disassembly of contaminated equipment, a glove box or room in which the decontamination can be accomplished, and a collection system with an adequate filter system would be needed to use this technology. Development cost: >$2M Capital cost: $500K-$1000K Operating cost: About $1/ft^2


• Cleanup Legacy
• Prevent Future Insult
• Develop Environmental Stewardship
EM Problem
Decommissioning (D&D)
Soils, Groundwater and Surface Water (RA)
Waste Management (WM)
Enrichment Process Building
Process Support Building
Electrical and Electrical Switch Gear
Pumping Stations
Laboratory Facilities
Special Development Facilities
Administrative Facilities
Cooling Towers
Ni-Lined Steel
Equipment Interior
U, Tc, Actinides
Steel
Chromate
Monel
U, Tc, Actinides
Copper
U, Tc, Actinides
Aluminum
U, Tc, Actinides, S, Cr
Steel Pipe
As, Chromates, Ba, Dioxins
Aluminum Pipe
U, S, Cr
Steel Cylinders
UF6, Tc, Actinides
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Decontamination
Thermal Substrate Removal
(fixed and transferrable contamination)
(cont.)
Surface Cleaning
(transferrable contamination)

→ Thermal Substrate Surface Removal (fixed and transferrable contamination) (cont.)	→ Plasma Surface Cleaning DCON-75-OG	→ **Pre-demonstration** Plasma surface cleaning by glow discharges is commonly and effectively utilized for cleaning high bonding energy contaminants from surfaces of metals prior to the operation of fusion devices. Technology is expected to be effective for removing deposits from listed substrates, but whether the plasma can follow the irregular shapes involved (compressors, etc.) is uncertain. Wastes would be the vaporized deposits plus filters and HEPA filters from the collection system.	→ Science - Data on cleaning rates for contaminants and substrates of interest are needed. Development - The capability of plasma generation and cleaning on surfaces of typical contaminated metals and equipment with large surface areas needs to b. established.	→ A collection system with appropriate filters for the vaporized deposits would be needed to use this technology. An electric power supply would be needed. Development cost: About $4M Capital cost: $500K-$1000K Operating cost: $0.50-$2.00/ft2
	→ Flashlamp Cleaning DCON-77-OG	→ **Evolving Technology** *Conceptual* - Flashlamp systems are being used to clean organic contamination from artwork, ship hulls, and precious metals. Hanford Westinghouse is conducting laboratory tests of xenon flashlamp systems for removing radionuclide contamination. Efficacy for listed contaminants on listed substrates is unknown. Wastes would be only the contaminants removed from the concrete contained in pre-filters and HEPA filters.	→ Science - Existing flashlamps should be tested on a small scale for removing the listed contaminants from concrete. Development - A moderate-scale demonstration of flashlamp decontamination using commercially available flashlamps with the associated vacuum collection system is needed.	→ A vacuum collection system would be needed to use this technology. Development cost: $1-4M Capital cost: $50K-$100K Operating cost: $0.50-$2.00/ft^2
→ Surface Cleaning (transferrable contamination)	→ High Pressure Water (5,000 TO 20,000 psi) DCON-52-OG	→ **Accepted** High pressure water blasting has been used very successfully to decontaminate various large and complex surfaces at nuclear power plants. Effectiveness of this technology for the listed contaminants and substrates is uncertain. DFs will be higher if chemical cleaning agents are also used. Waste would be 4 to >100 gpm of contaminated waste water.	→ Development - To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be reused.	→ Prior removal and disassembly of contaminated equipment and a glove box or room that is easily decontaminated in which the decontamination will be accomplished plus a water treatment system that will allow the water to be recycled are needed to use this technology. Development costs: About $1.2M Capital cost: High Pressure System: $50 - $75K Glove box: <$50K Work room: About $250K Operating cost: $0.06-$2/ft^2
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Technology Lo

Decontamin

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Building Process Support Building Electrical and Electrical Switch Gear Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Cooling Towers	Ni-Lined Steel Equipment **Interior** U, Tc, Actinides Steel Chromate Monel U, Tc, Actinides Copper U, Tc, Actinides Aluminum U, Tc, Actinides, S, Cr Steel Pipe As, Chromates, Ba, Dioxins Aluminum Pipe U, S, Cr Steel Cylinders UF_6, Tc, Actinides	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Surfa (trans conta (cont.)

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

Surface Cleaning (transferrable contamination) (cont.)	Compressed Air Cryogenic CO_2 Blasting DCON-51-OG	**Demonstration** This technology is commercially available. It has been used at nuclear reactor sites to decontaminate hand tools and some equipment. The efficacy of this technology for removing the listed contaminants from the listed substrates has not been demonstrated and is doubtful. Wastes would be HEPA filters filled with the removed contaminants.	Development - Demonstration of the efficacy of this technology for the listed contaminants and substrates.	Prior removal and disassembly of contaminated equipment and a glove box or room that is easily decontaminated in which the decontamination will be accomplished plus design and construction of a vacuum waste-handling system with HEPA filters to handle the vaporized CO_2 containing the removed contaminants are needed to use this technology. Oxygen depletion precautions are also needed. Development costs: \$750K-\$3000K Capital cost: CO_2 system: About \$200K Glove box: <\$50K Work room: About \$250K Operating cost: \$0.40-\$20/ft^2
	Superheated Water DCON-53-OG	**Accepted** Technology is available and has been used by industry. The removal of tightly bound or imbedded contaminants, such as the listed contaminants on the listed substrates is likely to be slight. Waste will be 0.4 to 2.0 gpm wastewater containing removed contaminants.	Development - To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be reused.	Prior removal and disassembly of contaminated equipment and a glove box or room that is easily decontaminated in which the decontamination will be accomplished plus a design and construction of a water recycle system are needed to use this technology. Development costs: About \$1.2M Capital cost: Superheated water system: About \$175K Glove box: <\$50K Work room: About \$250K Operating cost: \$0.05-\$2/ft^2
	Hot Water DCON-54-OG	**Accepted** Flushing with hot water is often used following scrubbing. The technique is not effective on fixed insoluble contamination. The waste generated is the contaminated water from the flushing operation.	Improvement - To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be recycled and reused in the hot water cleaning operation.	A water treatment system is needed to minimize liquid wastes from this technology. Development cost: About \$1.2M Capital cost: <\$5K Operating cost: <\$1/ft^2

Technology Log

Decontaminat

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alter
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Building Process Support Building Electrical and Electrical Switch Gear Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Cooling Towers	Ni-Lined Steel Equipment **Interior** U, Tc, Actinides Steel Chromate Monel U, Tc, Actinides Copper U, Tc, Actinides Aluminum U, Tc, Actinides, S, Cr Steel Pipe As, Chromates, Ba, Dioxins Aluminum Pipe U, S, Cr Steel Cylinders UF_6, Tc, Actinides	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Surface Cl (transferral (cont'd)

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram
ıtamination

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Surface Cleaning (transferrable contamination) (cont'd)	Steam DCON-55-OG	**Accepted** This technique has proven useful, especially on complex shapes and large surfaces. Technology is not expected to be effective for listed contaminants and substrates. Wastes would be 0.4 to 2.0 gpm waste water containing removed contaminants.	Development - To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be reused.	Prior removal and disassembly of contaminated equipment and a glove box or room that is easily decontaminated in which the decontamination will be accomplished plus a design and construction of a water recycle system are needed to use this technology. Development costs: About $1.2M Capital cost: Steam system: $50K-$75K Glove box: <$50K Work room: About $250K Operating cost: $0.05-$2/ft^2
	Hand Brushing DCON-56-OG	**Accepted** Brushing has been used to clean up loose contamination at K-25 for many years. Since little of the contamination is expected to be loose, this technology is not expected to be effective for this application. Waste would be spent contaminated brushes, HEPA filters from the vacuum system, and the removed contamination.	None	Disassembly of contaminated equipment and scraping, or some other dry means of loosening most contamination, as well as a vacuum collection system for dust generated would be needed to use this technology. Capital cost: Negligible Operating cost: $0.03-$1.00/ft^2
	Automated Brushing DCON-57-OG	**Demonstration** Brushing has been used to clean the interior of plutonium-contaminated pipe at Rocky Flats to a shiny metal. Brushing is effective for removing smearable contamination, and less effective for fixed contamination. The efficacy of brushing for removing the listed contaminants from the listed substrates inside equipment needs demonstration and is doubtful. Waste would be spent contaminated brushes, HEPA filters on the vacuum cleaner used to pick up the particles of contamination and substrate removed by the brushing, and these particles.	Development - A test to demonstrate that this technology will work for the listed contaminants on the listed substrates inside equipment should be made before a large capital investment is made.	Normal implementation needs. Development costs: $200K-$1000K Capital cost: $250K (Remote System) Operating cost: For pipe interiors about $12,000/linear foot including remote operation, containment, and remote viewing, based on Rocky Flats experience.

Technology Log

Decontamin

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

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Process Support Building

Electrical and Electrical Switch Gear

Pumping Stations

Laboratory Facilities

Special Development Facilities

Administrative Facilities

Cooling Towers

Problem Area/Constituents

Ni-Lined Steel
Equipment **Interior**
U, Tc, Actinides

Steel
Chromate

Monel
U, Tc, Actinides

Copper
U, Tc, Actinides

Aluminum
U, Tc, Actinides, S, Cr

Steel Pipe
As, Chromates, Ba, Dioxins

Aluminum Pipe
U, S, Cr

Steel Cylinders
UF_6, Tc, Actinides

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelements

Decontamination

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Logic Diagram
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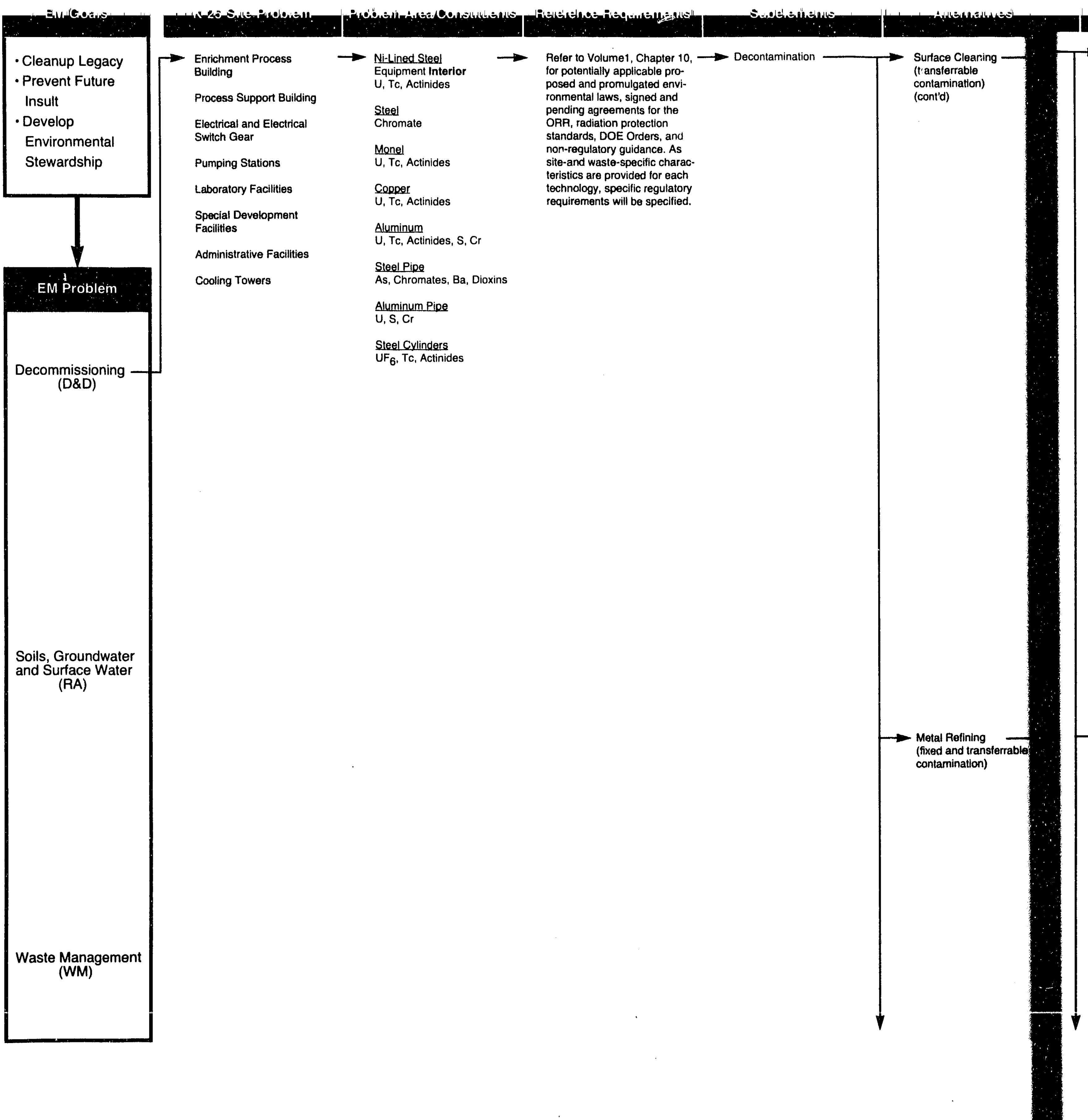
Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Surface Cleaning (transferrable contamination) (cont'd)	Sponge Blasting DCON-58-OG	**Accepted** Although the technology is relatively new, it is currently being used by, at least two sites, including a nuclear power plant. Extensive data on decontamination factors are not available, but the aggressive sponges, which are impregnated with abrasives, may be effective for the listed contaminants and substrates. Wastes consist of about 0.01 ft^3 of blasting media and removed contaminants per ft^2 of area decontaminated plus any liquid cleaning agents that may have been added to the sponges.	Development - To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be recycled and reused in the sponge blasting operation.	Prior removal and disassembly of contaminated equipment and a glove box or room that is easily decontaminated in which the decontamination will be accomplished plus a wastewater treatment/recycle system will be needed to use this technology. Development cost: About $1.2M Capital cost: Sponge blasting system: About $20K (with blasting media wash unit) Glove box: <$50K Work room: About $250K Operating cost: about $2/ft^2$
	Hot Air Stripping DCON-59-OG	**Evolving Technology** Conceptual- The basic hot air stripping technology is well know for volatiles in liquids and many commercial designs are readily available, but this technology has no known or proposed use for decontaminating equipment. Hot air might remove some technetium, but cannot be expected to remove any other contaminants. Waste would be HEPA filters and pre-filters containing any removed contaminants.	Science - Investigation of the conditions and removal efficiency for the removal of technetium and any other contaminants that might be removed is needed. Technology-Demonstration of the removal of technetium and any other contaminants from process equipment is needed. Development of an air cleanup system for removing the contaminants from the hot air is also needed.	An off-gas collection and treatment system would be needed to use this technology. Development cost: $3-5M Capital cost: About $200K Operating cost: $2-$20/ft^2$
	Dry Heat Roasting DCON-60-OG	**Demonstration** Although dry heat (roasting) is an accepted industrial process, its efficacy for removing the listed contaminants from the listed substrates is doubtful. Technology has some probability of success for Tc and little chance of success for the other contaminants. Waste would be any removed contaminants in filters and HEPA filters.	Development - Demonstration of the efficacy of the process; development and demonstration of an off-gas treatment system.	An off-gas collection and treatment system would be needed to use this technology. Development cost: $1-4M Capital cost: About $250K with collection and treatment system Operating cost: $2-20/ft^2$



EM Goals
K-25 Site Problem
Problem Area/Constituents
Reference Requirements
Subelements
Alternatives
• Cleanup Legacy
• Prevent Future Insult
• Develop Environmental Stewardship
EM Problem
Decommissioning (D&D)
Soils, Groundwater and Surface Water (RA)
Waste Management (WM)
Enrichment Process Building
Process Support Building
Electrical and Electrical Switch Gear
Pumping Stations
Laboratory Facilities
Special Development Facilities
Administrative Facilities
Cooling Towers
Ni-Lined Steel
Equipment Interior
U, Tc, Actinides
Steel
Chromate
Monel
U, Tc, Actinides
Copper
U, Tc, Actinides
Aluminum
U, Tc, Actinides, S, Cr
Steel Pipe
As, Chromates, Ba, Dioxins
Aluminum Pipe
U, S, Cr
Steel Cylinders
UF_6, Tc, Actinides
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Decontamination
Surface Cleaning (transferrable contamination) (cont'd)
Metal Refining (fixed and transferrable contamination)

Logic Diagram

tamination

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Surface Cleaning (transferrable contamination) (cont'd)	Solvent Washing DCON-61-OG	**Evolving Technology -** Conceptual- Solvent degreasing was used successfully at K-25, but its use was stopped to avoid exposing workers and the environment to the hazardous solvents. The effectiveness of less hazardous solvents would have to be demonstrated. Solvents are not expected to successfully remove the listed contaminants from the listed substrates. Wastes would be the solvents containing removed contaminants.	Development - Solvents that are less damaging to the environment need to be identified and their effectiveness demonstrated.	Requires removal and disassembly of contaminated equipment and size reduction to roughly 2 tons/piece for processing. Spent solvents would have to be "burned" at the TSCA incinerator. Development costs: \$1-4.5M Capital cost: About \$400K Operating cost: About \$0.01/lb
	Strippable Coatings DCON-63-OG	**Accepted** Technology has been used for decontamination applications involving hazardous and radioactive contaminants. Decontamination factors of one to several hundred can be expected with two applications. Waste is a solid polymer (1mm x surface are decontaminated) containing the removed contaminants.	None	Requires removal, disassembly, and possibly some size reduction of contaminated equipment. Capital cost: <\$10K Operating cost: \$1.00-\$1.40/ft²
	Ultrasonic Cleaning DCON-66-OG	**Accepted** Ultrasonic cleaning has been used for many years in the private sector and in government installations for removing surface contamination from relatively small metal parts which can fit into an ultrasonic bath. Ultrasonic cleaning is not expected to be effective for the listed contaminants on the listed substrates. Wastes would be spent ultrasonic baths containing any removed contaminates.	Development - Definition of acceptable cleaning liquids which (1) are not hazardous, (2) can be separated from the contaminants, and (3) can be reused to minimize secondary wastes. Improvement - More aggressive cleaning action.	Requires removal, disassembly, and size reduction of contaminated equipment. Development cost: \$1M Capital cost: \$10K-\$100K Operating cost: \$2-\$10/ft² or more
Metal Refining (fixed and transferrable contamination)	Smelt Purification DCON-31-OG	**Demonstration** Performed by many investigators on a lab scale and by some on a large scale. U removed to 0.01-4ppm. Tc is not removed. Wastes are slags, scrubber solutions, chemical trap materials and HEPA filters.	Science - Demonstrate fluxing agent for removing Tc. Development - Demonstrate Tc removal on a larger scale.	Requires removal, disassembly, and size reduction of equipment. Partial decontamination by another technique may be needed before smelting. Standard induction or arc furnace with off-gas treatment system is needed. *De minimus* limits are needed to release the material. Development cost: \$3-5M Operating plus capital cost is about \$1/lb.

Technology Lo

Decontamin

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

Enrichment Process Building

Process Support Building

Electrical and Electrical Switch Gear

Pumping Stations

Laboratory Facilities

Special Development Facilities

Administrative Facilities

Cooling Towers

Problem Area/Constituents

Ni-Lined Steel
Equipment Interior
U, Tc, Actinides

Steel
Chromate

Monel
U, Tc, Actinides

Copper
U, Tc, Actinides

Aluminum
U, Tc, Actinides, S, Cr

Steel Pipe
As, Chromates, Ba, Dioxins

Aluminum Pipe
U, S, Cr

Steel Cylinders
UF_6, Tc, Actinides

Reference Requirements

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Subelements

Decontamination

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Metal Refining (fixed and transferrable contamination)	Electrorefining DCON-32-OG	**Pre-demonstration** Not demonstrated on a large scale for the decontamination of radioactive materials. Tc plates out on the cathode. Technology is likely to be effective for the listed contaminants and substrates. Waste would be solid mixed waste from assumed treatment of electrolyte solutions for recycle.	Development - Demonstrate techniques to (1) prevent Tc from plating out with Ni and Al; (2) reduce U contamination in refined Al; and (3) recycle electrolytic solutions.	Smelter is needed to cast anodes Development cost: About $3M Capital cost: About $200M (10 million lb/yr capacity) Operating cost: About $6/lb
	Leach/Electrowinning DCON-34-OG	**Pre-demonstration** The method is similar to electrorefining except the metal is first dissolved into solution rather than formed into anodes. Although this process is a well established commercial process for producing nickel from ore, it has not been demonstrated on a large scale for purifying metals contaminated with radioactivity. Ni was purified to <1 Bq/g of Tc on a small scale. The Tc must be removed from the electrolytic solutions by ion exchange or some other method. Recycle of electrolytic solutions will result in a solid mixed waste bearing the contaminants and traces of the purified metal amounting to roughly 2% by weight of the metal purified.	Development - Demonstrate techniques to recycle the electrolytic solutions.	A de minimus standard is needed to permit sale of the purified metal. Development costs: About $500K Capital cost: $200M (10M lb/yr plant) Operating cost: $3.80/lb
Chemical Surface Cleaning (fixed and transferrable contamination)	Chemical Foams DCON-8-OG	**Demonstration** Effectiveness for listed contaminants and substrates has not been demonstrated and is doubtful. Wastes would be contaminated sulfonated detergents, synthetic wetting agents, and coupling agents plus removed contaminants.	Science - A fundamental understanding of bubble dimensions and volume swell factor is needed. Development - Demonstration of effective in situ decontamination of listed contaminants on listed substrates with adequate control of bubble dimensions and volume swell factor	Normal implementation needs. Development cost : $1-4M Capital cost: <$50K Operating cost: $0.50-$2.00/ft^2

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

Enrichment Process Building

Process Support Building

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Pumping Stations

Laboratory Facilities

Special Development Facilities

Administrative Facilities

Cooling Towers

Ni-Lined Steel
Equipment **Interior**
U, Tc, Actinides

Steel
Chromate

Monel
U, Tc, Actinides

Copper
U, Tc, Actinides

Aluminum
U, Tc, Actinides, S, Cr

Steel Pipe
As, Chromates, Ba, Dioxins

Aluminum Pipe
U, S, Cr

Steel Cylinders
UF_6, Tc, Actinides

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Decontamination

Chemical Surface (fixed and transfer contamination) (cont.)

Logic Diagram
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Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Chemical Surface Cleaning (fixed and transferrable contamination) (cont.)	Gas Phase Decon DCON-16-OG	**Pre-demonstration** Lab-scale studies have demonstrated that ClF_3 is capable of effectively removing U deposits at room temperat···. Gas phase decontaminatio·. is expected to be largely or completely effective in removing U and S compounds found in gaseous diffusion and gas centrifuge equipment. It should not be effective in removing Tc. Chromates, actinides, and thorium daughter products from the decay of U compounds will not be removed. The levels of the latter contaminants on much, or most, of the substrates are expected to be low enough that these substrates will still meet surface release criteria. Wastes will be spent NaF trapping material and spent caustic scrubber solution or fluoride trapping media.	Science - Optimum process conditions for decontamination should be established. Development - Full-scale demonstration of the decontamination of process equipment is needed. Development of mechanical methods and chemical methods to remove reaction by products so that ClF_3 can be recycled are needed.	A permitted vent will be needed to implement this technology. Air with trace amounts of UF_6, chlorides, and fluorides will be vented. Development cost: About $5M Capital cost: >$3M Operating cost: About $15,000 ($0.52/lb) if a 00 converter is treated in situ.
	Inorganic Acid Treatments DCON-12-OG	**Accepted** Decontamination with nitric acid has been used for cleaning converters and other large items at K-25 for many years. Sulfuric acid is used less often, notably to dissolve nickel plating prior to removing contaminants at the nickel-steel interface. The inorganic acids are concentrated, with concurrent corrosion. DFs are in the 100 range. Wastes consist of large quantities of corrosive wastes containing the removed contaminants and require treatment and disposal as mixed waste.	Development- Necessary to adapt modifications to the system (scrubbers, filters, treatment for nitrates and heavy metals) in order to meet regulatory requirements. Science/Development- Possible development of the HNO_3/HF decontamination method, with or without ultrasonic agitation.	Normal implementation needs. Development Cost: $400-1000K (Rough estimate) Capital Cost: $4-10 million (Rough estimate) Although existing facilities may be adaptable to the acid cleaning process, a treatment facility for corrosive nitrate wastes will be required. Operating cost: Similar to the other organic and inorganic treatment systems.
	Organic Acid Treatments DCON-10-OG	**Demonstration** The BNFL citric acid decontamination process is currently used by BNFL at the Capenhurst gaseous diffusion plant for large scale, successful decontamination of wrought aluminum. DF of 300 for U alpha and 40 for Tc beta are reported (11.1 Bq/g alpha, 0.04 Bq/g beta). A 2.5 hectare area of the Capenhurst plant was decontaminated by this process. A citric acid process followed by a sulfuric acid process is used. Wastes include citric and sulfuric acids containing uranium and other metal ions and ion exchange media containing the metals. Uranium is difficult to precipitate.	Development - Development is needed on a pilot plant scale for waste treatments (ion exchange columns) to verify that we can meet our regulatory requirements and to evaluate the effectiveness on the metals used by American gaseous diffusion plants, which differ from the British plants.	Normal implementation needs. Development cost: $400-1000K (rough estimate). Capital cost: $4-10 million (rough estimate). Operating cost: approximately $300/metric ton.(BNFL estimate) Existing facilities may possibly be adapted to this process at K-25.

Technology Lo

Decontamin

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

Enrichment Process Building

Process Support Building

Electrical and Electrical Switch Gear

Pumping Stations

Laboratory Facilities

Special Development Facilities

Administrative Facilities

Cooling Towers

Problem Area/Constituents

Ni-Lined Steel
Equipment **Interior**
U, Tc, Actinides

Steel
Chromate

Monel
U, Tc, Actinides

Copper
U, Tc, Actinides

Aluminum
U, Tc, Actinides, S, Cr

Steel Pipe
As, Chromates, Ba, Dioxins

Aluminum Pipe
U, S, Cr

Steel Cylinders
UF_6, Tc, Actinides

Reference Requirements

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Subelements

Decontamination

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Chemical Surface Cleaning (fixed and transferrable contamination) (cont'd)	Fluoboric Acid Treatment DCON-11-OG	**Demonstration** The technology was specifically designed for D&D (Chernobyl application) and is likely to be highly effective on most metal and metallic oxide surfaces. It removes the outer layer in a controlled and effective manner. The acid can be electrolytically regenerated and recycled with radioactive waste plated out at the cathode and solidified in cement. Final quantity of cement-solidified waste is 20-50 grams/square meter of decontamination surface. Other waste treatment options are possible.	Development-Although the method has seen application at Chernobyl with good results, development work is needed to test applicability to US GDP equipment.	Normal implementation needs. Development cost: \$400-1000K (rough estimate) Capital Cost: 800K (1990 estimate for equipment only for 5T/day capacity of metal) \$4-10M (rough estimate including engineering & facilities) Operating Cost: ~\$300 metric ton (assume same as for BNFL process)
	Caustic Treatments DCON-13-OG	**Accepted** Decontamination of surface smearable contamination using caustic chemicals (principally soap and water) has been used at K-25 for many years. Since many of the listed contaminants are expected to be fixed or to have penetrated, at least partially, into the substrate, caustic scrubbing is expected to only partially decontaminate the contaminated substrate. Wastes would consist of used caustic solution containing the removed contaminants.	Development-Test with fluoride films.	A waste treatment plant is needed to treat the wastewater resulting from the decontamination operation. Capital cost: <\$10K Operating cost: >\$1/ft^2
	REDOX Treatments DCON-14-OG	**Demonstration** REDOX treatments include Citrox (a mixture of oxalic and citric acids), low oxidation-state metal ion process, and cerium solutions in acid. REDOX treatments have been demonstrated for nuclear power plant decontamination, but not for the contaminants of interest. DFs of 10-100 may be expected based on experience in nuclear power plants. With recycle, waste is spent ion exchange media containing removed contaminants. With neutralization and evaporation, a solid mixed waste containing the removed contaminants and chemicals from the REDOX reagents.	Development - All REDOX techniques will require bench-scale testing and small-scale demonstrations to determine their usefulness for decontamination of gaseous diffusion equipment.	A system for treating the REDOX reagents to permit recycling these reagents will be needed to use this technology. Development costs: \$2.5-\$5.0M Capital costs: >\$1M Operating cost: About \$1/ft^2

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

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Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

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Special Development Facilities

Administrative Facilities

Cooling Towers

Ni-Lined Steel
Equipment **Interior**
U, Tc, Actinides

Steel
Chromate

Monel
U, Tc, Actinides

Copper
U, Tc, Actinides

Aluminum
U, Tc, Actinides, S, Cr

Steel Pipe
As, Chromates, Ba, Dioxins

Aluminum Pipe
U, S, Cr

Steel Cylinders
UF_6, Tc, Actinides

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Decontamination

Chemical Surfac
(fixed and transfe
contamination)
(cont'd)

Bulk Decontamina
Methods
(fixed and transfe
contamination)

Logic Diagram
tamination

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Chemical Surface Cleaning (fixed and transferrable contamination) (cont'd)	Electropolishing DCON-15-OG	**Demonstration** Electropolishing is widely used to remove radioactive contaminants from metal surfaces but has not been demonstrated at the US GDPs. The method is very likely to be successful, since it results in removing a small depth of the surface. Acidic solutions will be generated which must be recycled, perhaps by ion exchange methods.	Development - Some development work is required to apply the method to US GDP applications, and to recycle electrolytic solutions	Normal implementation needs Development cost: $400-1000K (Rough estimate) Capital cost: not available (can be constructed in modules easily) Operating cost: more expensive than most other methods since items must be subjected to electric current.
	Biological DCON-17-OG	**Evolving Technology** -preconceptual- Organisms that destroy organics have been identified. Method is unlikely to remove U, Tc. Waste would be a sludge containing remains of bacteria + PCBs and inorganic contaminants. Methane is a likely gaseous product.	Science - Find culture techniques that provide successful decon on a lab scale. Development - Develop techniques that successfully decon on large scale. Develop equipment cost and decon rate and cost information.	Facilities for cultivating the bacteria and disposing of the bacterial sludge would be needed. Development cost: $300K-$600K/year Capital cost: about $200K Operating cost: $0.10-$3.00/ft^2
	Laser Activated Chemistry DCON-18-OG	**Evolving Technology-** Acceleration of reaction rates for selected reactions is proven. Small scale decon has been demonstrated. Waste would be prefilters and HEPA filters filled with removed contaminants.	Development - Demonstration of vacuum systems capable of collecting removed contaminants.	Vacuum systems capable of collecting removed contaminants. Development costs: $2M + Capital cost: $1-10M/machine Operating cost: Unknown
Bulk Decontamination Methods (fixed and transferrable contamination)	Catalytic Extraction Process DCON-6-OG	**Predemonstration** Has not been used to smelt scrap bearing radioactivity. Likely to reduce Ni to 0.01-4 ppm U and Al to 3-100 ppm U or less. Tc is not removed. Waste would be slag containing contaminants plus contaminants in a scrubber solution or chemical trapping materials.	Science - Method for removing Tc. Development - Demonstrate Tc removal and improve U removal from aluminum.	"Off the shelf" induction or arc furnace. Development cost : $3-5 million Capital cost: ~$16 million Operating cost: $1/lb

Technology Log

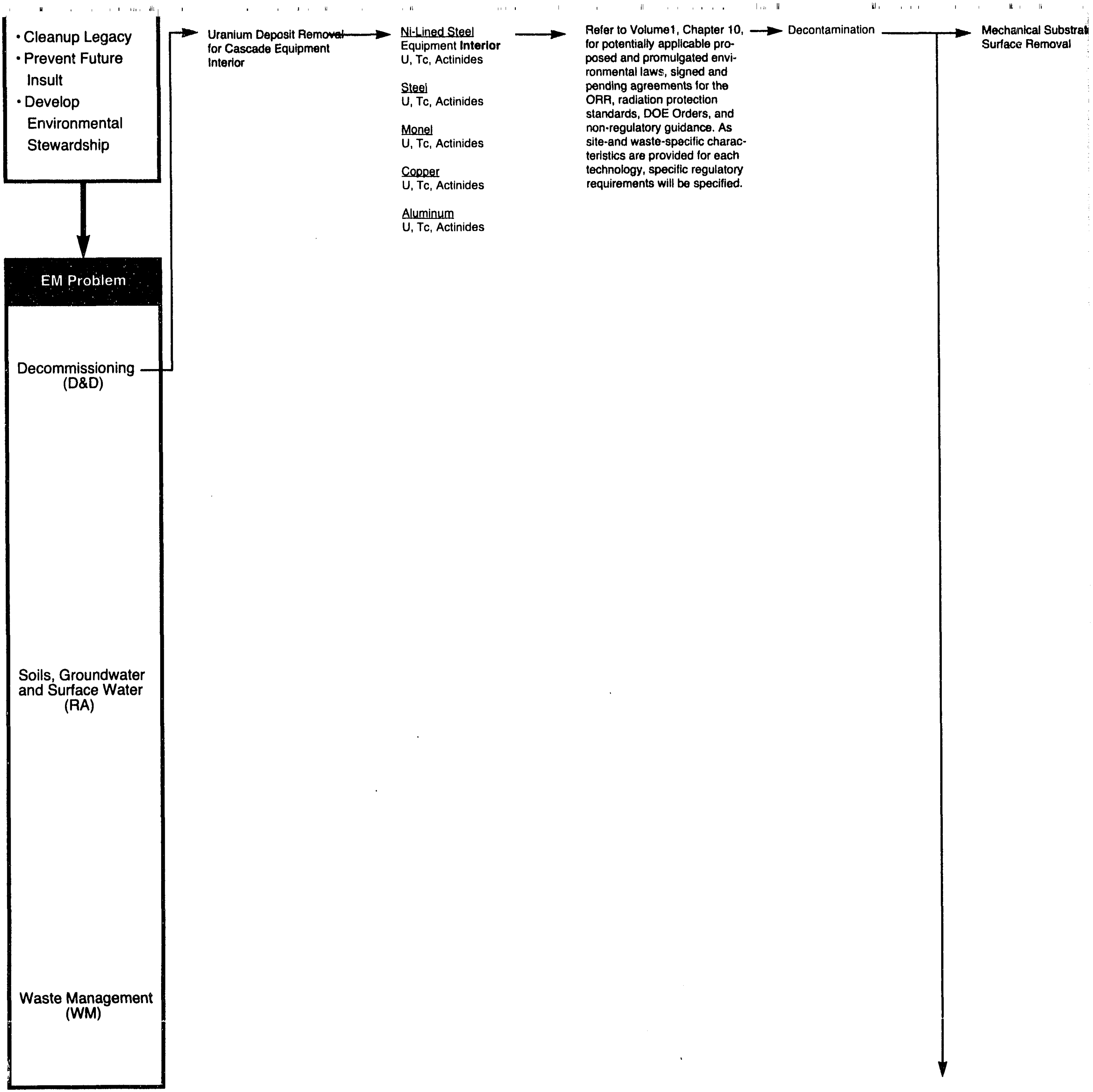
Decontamin

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Uranium Deposit Removal for Cascade Equipment Interior	Ni-Lined Steel Equipment Interior U, Tc, Actinides Steel U, Tc, Actinides Monel U, Tc, Actinides Copper U, Tc, Actinides Aluminum U, Tc, Actinides	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Mecha Surfac

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Mechanical Substrate Surface Removal	Shot Blasting DCON-36-OG	**Accepted** Commercial shot blasters are used to remove rust and marine growth from ship hulls and to clean structural steel. Waste is about 0.1 lb spent shot/ft^2 decontaminated, removed deposits, trace amounts of eroded substrate, filters, and HEPA filters.	Improvement - Vacuum/filter systems with nozzles designed to match decontaminated parts are needed to minimize the spread of shot and contamination.	Equipment must be removed and partially disassembled. An enclosed glovebox that has adequate filters and is easily decontaminated on the inside is needed in which the shot blaster system will be used. Development cost: $200-1000K (Vacuum system for each nozzle design) Capital cost: Shot blaster: > $50K (with vacuum system) Glove box: <$50K Operating cost: About $1.00/ft^2
	Scabblers/Scarifiers DCON-37-OG	**Accepted** Mechanical scabblers are widely used. They are generally effective, but leave some hot spots. Noise would be a problem. Waste would be removed deposit, trace amounts of eroded substrate, scabbler bits, filters, and HEPA filters.	Improvement - Scabbler heads, vacuum systems with nozzles designed to match decontaminated parts, and filters are needed to minimize the spread of contamination.	Equipment must be removed and partially disassembled. An enclosed glovebox with adequate filters that is easily decontaminated on the inside is needed in which the mechanical scabbler system will be used. Development cost: $300-1000K (Vacuum system and scabbler head for each design required) Capital cost: Scabbler: > $50K (with vacuum system) Glove box: <$50K Operating cost: About $1.00/ft^2 (greater than for shot blaster)
	Grit Blasting DCON-38-OG	**Accepted** Has been used for many applications in the nuclear industry. Technology is generally effective. Waste would be removed deposits, trace amounts of eroded substrate, spent grit, filters, and HEPA filters.	Improvement - 1) Better vacuum/filter systems for collecting blast media are needed to minimize spread of blast media and contamination. 2) A system to separate contaminants from blast media and package the wastes is needed.	Equipment must be removed and partially disassembled. An enclosed glovebox that is easily decontaminated on the inside is needed in which the grit blaster system will be used. A system to separate contaminants from blast media and package the wastes is needed as well as a system to adequately filter the exhaust air. Development costs: 1) better vacuum/filtration systems: $1-6M, 2) Waste treatment and packaging: About $4M Capital cost: About $500K Operating cost: >$2/ft^2



• Cleanup Legacy
• Prevent Future Insult
• Develop Environmental Stewardship
EM Problem
Decommissioning (D&D)
Soils, Groundwater and Surface Water (RA)
Waste Management (WM)
Uranium Deposit Removal for Cascade Equipment Interior
Ni-Lined Steel
Equipment Interior
U, Tc, Actinides
Steel
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U, Tc, Actinides
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Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Decontamination
Mechanical Substrat
Surface Removal

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Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Mechanical Substrate Surface Removal	Centrifugal Cryogenic CO_2 Blasting DCON-39-OG	**Pre-demonstration** Centrifuge pellet acceleration has been demonstrated. Technology will be likely successful with essentially infinite decontamination factors. Waste would be filters and HEPA filters filled with removed deposits and a small amount of substrate, which would also be removed.	Development - Demonstration of a practical system with high-velocity pellets delivered at a sufficient rate and adequate collection of removed contaminants.	Prior removal and disassembly of contaminated equipment and a glove box that is easily decontaminated in which the decontamination will be accomplished plus oxygen depletion precautions and adequate filtration are needed to use this technology. Development costs: <$3.4M Capital cost: Centrifuge CO_2 system: About $200K Glove box: <$50K Operating cost: $0.50-$1.50/ft^2
	Supercritical CO_2 Blasting DCON-41-OG	**Pre-demonstration** This technology is being developed by a private company. Likely to be effective with large decontamination factors. Waste would be removed deposits and a small amount of the substrate contained in a cyclone and HEPA filters.	Development - Investigate the effect of operating parameters on removal rates and removal and collection efficiencies for contaminants. Demonstrate efficacy for deposits on substrates of interest.	Prior removal and disassembly of contaminated equipment and a glove box that is easily decontaminated in which the decontamination will be accomplished plus oxygen depletion precautions and adequate filtration are needed to use this technology. Development costs: $250K-$1000K Capital cost: Supercritical CO_2 system: $500-$1000K Glove box: <$50K Operating cost: >$2/ft^2
	Plastic Pellet Blasting DCON-42-OG	**Accepted** Plastic pellet blasting is a widely used alternate to sand blasting for applications in which it is desired to impart minimal damage to the substrate. Technology is likely to remove most, but not all, of the deposits from the listed substrates. Waste would be spent plastic pellets, removed deposits, filters, and HEPA filters.	Improvement - 1) Minimize blast media erosion to minimize waste; 2) Better vacuum/filter systems for collecting blast media are needed to minimize spread of blast media and contamination.	Prior removal and disassembly of contaminated equipment, a glove box that has adequate filtration of effluent air and is easily decontaminated in which the decontamination will be accomplished, and a system for processing wastes to an acceptable form are needed to use this technology. Development costs: $250K-$1000K Capital cost: Plastic pellet blasting system: About $50K Glove box: <$50K Operating cost: $2-$5/ft^2

Technology Lo

Decontamin

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
Uranium Deposit Removal for Cascade Equipment Interior	Ni-Lined Steel Equipment **Interior** U, Tc, Actinides Steel U, Tc, Actinides Monel U, Tc, Actinides Copper U, Tc, Actinides Aluminum U, Tc, Actinides	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Mecha Surfac Therm Remov

Mechanical Substrate Surface Removal	Hand Grinding, Honing, Scraping DCON-43-OG	**Accepted** Hand grinding and scraping have been used successfully for small-scale decontamination at K-25. Technology is successful. Waste would be removed substrate and deposits plus contaminated HEPA filters.	None	Prior removal and disassembly of contaminated equipment and a glove box that is easily decontaminated and has HEPA filters in which the decontamination will be accomplished plus a system for processing wastes to an acceptable form are needed to use this technology. Capital cost: Grinder: $150 Glove box: <$50K Operating cost: About $2/ft2
Thermal Substrate Surface Removal	Plasma Torch DCON-72-OG	**Evolving Technology** Conceptual - Plasma torches exist commercially to weld and cut materials that either have a very high melting temperature or require an inert atmosphere to prevent oxidation. Plasma torches have not been used to decontaminate metal but can be expected to do so effectively by melting or vaporizing the surface layer, including the contaminants. Waste would be vaporized or melted metal, removed deposits, and contaminated filters and HEPA filters.	Development - The efficacy of a plasma torch in removing deposits should be demonstrated on a bench scale. A method for collecting the removed substrate and contaminants is needed.	Prior removal and disassembly of contaminated equipment, a glove box in which the deposit removal is accomplished, and a collection system with an adequate filter system would be needed to use this technology. Development cost: About $3M Capital cost: Plasma torch and collection system: About $200K Glove box: <$50K Operating cost: $0.20-$5/ft2
	Laser Heating DCON-73-OG	**Pre-demonstration** Decontamination of metals by surface removal has been demonstrated on a bench scale. Technology should be effective. The waste would be filters and HEPA filters containing the removed substrate and deposits.	Development - Existing laser based photothermal methods should be demonstrated on a larger scale. Lasers with different operating parameters should be tested on a bench scale to evaluate whether more efficient laser systems exist.	Prior removal and disassembly of contaminated equipment, a glove box in which the deposit removal is accomplished, and a collection system with an adequate filter system would be needed to use this technology. Development cost: Over $2M Capital cost: $500K-$1000K Operating cost: About $1/ft^2
	Laser Etching and Ablating DCON-74-OG	**Pre-demonstration (evolving technology)** - The conceptual basis for this technology exists, and a similar technique is used to clean optical surfaces and microelectronics. Technique may be slow to remove large deposits. Wastes would be removed deposit, traces of removed substrate, and filters and HEPA filters from the filtration system.	Development: Existing lasers, optics, and vacuum and filtration systems need integration into a system; then, this system should be demonstrated.	Prior removal and disassembly of contaminated equipment, a glove box in which the deposit removal is accomplished, and a collection system with an adequate filter system would be needed to use this technology. Development cost: Over $2M Capital cost: $500K-$1000K Operating cost: About $1/ft^2

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

Uranium Deposit Removal for Cascade Equipment Interior

Ni-Lined Steel
Equipment **Interior**
U, Tc, Actinides

Steel
U, Tc, Actinides

Monel
U, Tc, Actinides

Copper
U, Tc, Actinides

Aluminum
U, Tc, Actinides

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Decontamination

Thermal Substrate Su
Removal

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amination

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Thermal Substrate Surface Removal	Plasma Surface Cleaning DCON-75-OG	**Pre-demonstration** Plasma surface cleaning by glow discharges are commonly and effectively utilized for cleaning high bonding energy contaminants from surfaces of metals prior to the operation of fusion devices. Technology is expected to be effective for removing deposits from listed substrates, but whether the plasma can follow the irregular shapes involved (compressors, etc.) is uncertain. Wastes would be the vaporized deposits plus filters and HEPA filters from the collection system.	Science - Data on cleaning rates for contaminants and substrates of interest are needed. Development - The capability of plasma generation and cleaning on complex internal surfaces of contaminated equipment with large surface areas needs to be established.	A collection system with appropriate filters for the vaporized deposits would be needed to use this technology. An electric power supply would be needed. Development cost: About $4M Capital cost: $500K-$1000K Operating cost: $0.50-$2.00/ft^2
	Plasma Etching/Fluorination DCON-76-OG	**Pre-demonstration** Plasma etching processes are used in material processing and microelectronic manufacturing. Extrapolating these plasma processes for vaporizing and recovering uranium deposits is considered feasible. Reactive plasma decontamination rates should be higher than unassisted gas-phase decontamination rates. Wastes would be the vaporized deposits plus filters and HEPA filters from the collection system.	Science - Data on cleaning rates for contaminants and substrates of interest are needed. Development - The capability of plasma etching on deposits in complex equipment with large surface areas needs to be established.	A collection system with appropriate filters for the vaporized deposits would be needed to use this technology. An electric power supply would be needed. Development cost: About $10M Capital cost: About $2M Operating cost: $0.50-$2.00/ft^2
	Flashlamp Cleaning DCON-77-OG	**Pre-demonstration** (emerging technology) - Flashlamp systems are being used to clean organic contamination from artwork, ship hulls, and precious metals. Hanford-Westinghouse is conducting laboratory tests of xenon flashlamp systems for removing radionuclide contamination from surfaces inside metal storage vessels. Wastes would be removed deposit, traces of removed substrate, and filters and HEPA filters from the filtration system.	Development - Commercially available flashlamp systems would have to be evaluated for possible use for deposit removal.	A collection system with appropriate filters for the vaporized deposits would be needed to use this technology. An electric power supply would be needed. Capital cost: $50K-$100K Operating cost: $0.50-$2.00/ft^2

Technology Lo

Decontamin

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

Uranium Deposit Removal for Cascade Equipment Interior

Problem Area/Constituents

Ni-Lined Steel Equipment **Interior**
U, Tc, Actinides

Steel
U, Tc, Actinides

Monel
U, Tc, Actinides

Copper
U, Tc, Actinides

Aluminum
U, Tc, Actinides

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelements

Decontamination

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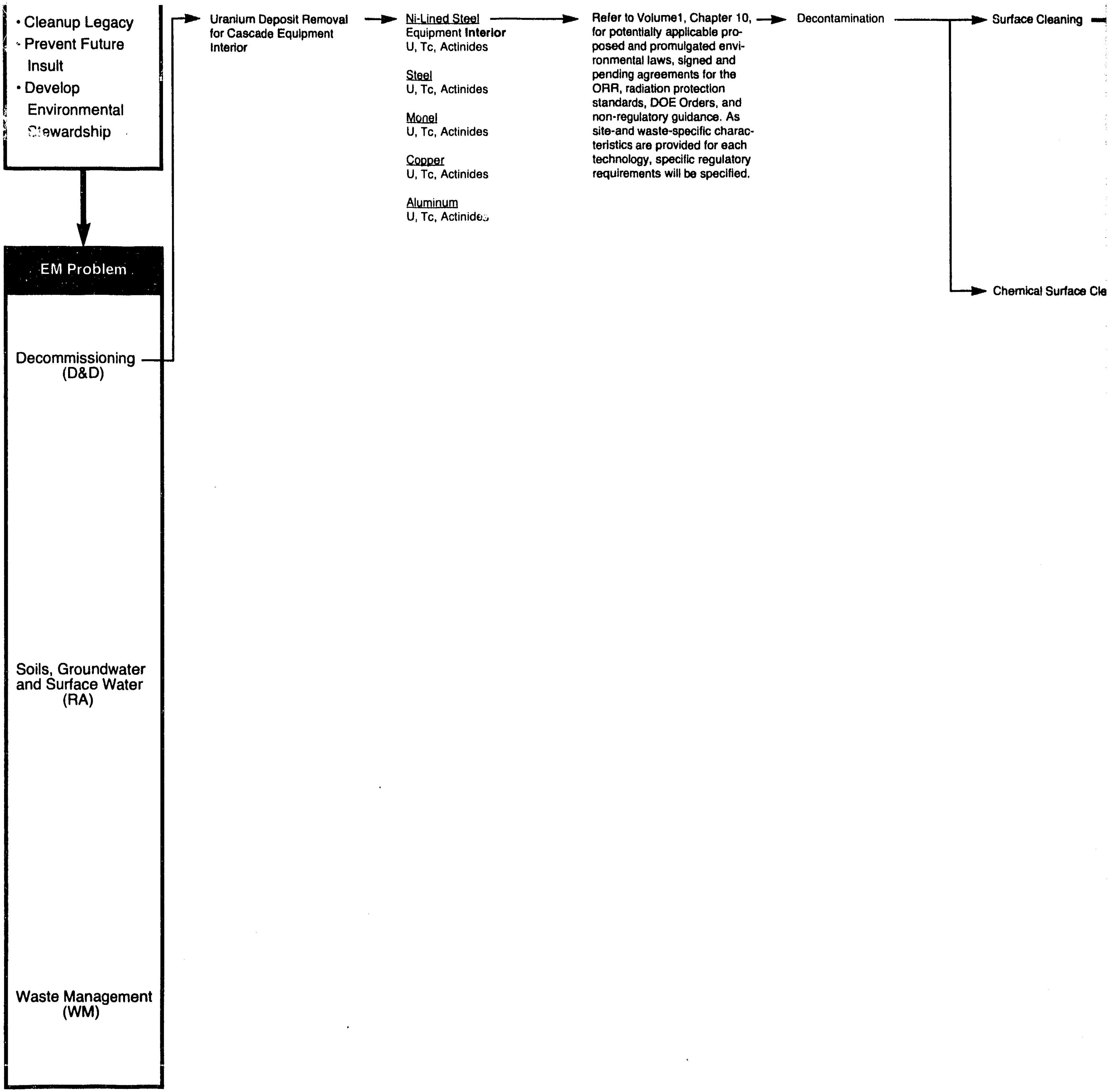
Surface Cleaning	Compressed Air Cryogenic CO2 Blasting DCON-51-OG	**Demonstration** This technology is commercially available. It has been used at nuclear reactor sites to decontaminate hand tools and some equipment. The efficacy of this technology for removing large uranium deposits from the listed substrates has not been demonstrated. Wastes would be filters and HEPA filters filled with the removed deposits.	Development - Demonstration of the efficacy of this technology for removing large uranium deposits from the listed substrates.	Prior removal and disassembly of contaminated equipment and a glove box that is easily decontaminated in which the decontamination will be accomplished plus design and construction of a vacuum waste-handling system with filters and HEPA filters to handle the vaporized CO_2 containing the removed deposits are needed to use this technology. Development costs: $750K-$3000K Capital cost: CO2 system: About $200K Glove box: <$50K Operating cost: $2-$20/ft^2
	Hand Brushing DCON-56-OG	**Accepted** Brushing has been used to clean up loose contamination at K-25 for many years. Waste would be spent contaminated brushes, HEPA filters on the vacuum system of the glove box, and the removed contamination.	None.	Disassembly of contaminated equipment and scraping, or some other means of loosening most deposits would be needed to use this technology. Capital cost: Negligible Operating cost: $0.03-$1.00/ft^2
	Sponge Blasting DCON-58-OG	**Accepted** Although the technology is relatively new, it is currently being used by, at least two sites, including a nuclear power plant. Extensive data on decontamination factors are not available, but the aggressive sponges, which are impregnated with abrasives, may be effective for uranium deposits on the listed substrates. Wastes consist of spent sponges, any materials (grit, washing solution, etc.) added to the sponges, removed deposits, trace amounts of the substrate, and about 0.01 ft^3 of blasting media per ft^2 of area decontaminated.	Development - 1) Better vacuum/filter systems for collecting blast media are needed to minimize spread of blast media and contamination; 2) to minimize waste generation, a water treatment system is needed for decontamination of the wash solution.	Prior removal and disassembly of contaminated equipment and a glove box or room that is easily decontaminated in which the decontamination will be accomplished plus a vacuum collection system with adequate effluent filtration will be needed to use this technology. Development costs: Vacuum/filter system: About $1.2M Recycle system: About 1.2M Capital cost: Sponge blasting system: About $20K (with blasting media wash unit) Glove box: <$50K Operating cost: $2-$5/ft^2


• Cleanup Legacy
• Prevent Future Insult
• Develop Environmental Stewardship
EM Problem
Decommissioning (D&D)
Soils, Groundwater and Surface Water (RA)
Waste Management (WM)
Uranium Deposit Removal for Cascade Equipment Interior
Ni-Lined Steel Equipment Interior
U, Tc, Actinides
Steel
U, Tc, Actinides
Monel
U, Tc, Actinides
Copper
U, Tc, Actinides
Aluminum
U, Tc, Actinides
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Decontamination
Surface Cleaning
Chemical Surface Cle

Surface Cleaning	Vacuuming DCON-64-OG	**Accepted** Vacuum cleaners have long been used to clean up loose contamination at the GDPs. Since little of the deposits are expected to be in loose form, deposits will have to be loosened by scraping or grinding before this technology is used. Critically safe vacuum cleaners should be an effective way to pick up deposits loosened by some other technology. Wastes would be the removed deposit and filters and/or HEPA filters on the vacuum cleaner.	None	Disassembly of contaminated equipment and prior loosening of the deposits using another technology is needed to use this technology. Capital cost: <$10K Operating cost: >$1/ft^2
Chemical Surface Cleaning	Gas Phase DCON-16-OG	**Pre-demonstration** Lab-scale studies have demonstrated that ClF3 is capable of effectively removing U deposits at room temperature. It should not be effective in removing Tc. Thorium daughter products from the decay of U compounds will not be removed. Wastes will be spent NaF trapping material and spent caustic scrubber solution or fluoride trapping media.	Science - Optimum process conditions for decontamination should be established. Process success on additional substrates should be verified in the lab. Development - Full-scale demonstration of the decontamination of process equipment is needed. Development of mechanical methods and chemical methods to remove reaction by-products so that ClF3 can be recycled are needed.	A permitted vent will be needed to implement this technology. Air with trace amounts of UF_6, chlorides, and fluorides will be vented. Development cost: About $5M Capital cost: >$3M Operating cost: About $15K ($0.52/lb) for an item the size of a 00 converter treated in situ.
	Laser Activated Chemistry DCON-18-OG	**Pre-demonstration** (evolving technology) - The conceptual basis for the technology exists. Laser activated chemistry is a proven technique for accelerating chemical reaction rates and for selecting reaction channels with many industrial applications, but its use for radiological decontamination is unproven. Deposit removal is likely to be slow, and redeposition is expected to be a problem. Waste will be only the deposits removed and filters and HEPA filters from the vacuum/exhaust system.	Development - Off-the-shelf equipment items need to be brought together to demonstrate an operable system.	Prior removal and disassembly of contaminated equipment and a glove box or room that is easily decontaminated in which the decontamination will be accomplished plus a vacuum collection system with adequate effluent filtration will be needed to use this technology. Development costs: Several million dollars Capital cost: $500-$1000K Operating cost: About $1/ft^2

Technology Lo L

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Building Process Support Building Electrical and Electrical Switch Gear Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Cooling Towers	Steel Metal Oil, PCBs, U, Tc, Actinides Structural Steel U, Oil, Tc, PCBs, Actinides Metal Equipment (Exterior) U, Oil, Tc, PCBs, Actinides Copper Oil	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Mecha Surfac (fixed contai

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Mechanical Substrate Surface Removal (fixed and transferrable contamination)	Ultra High-Pressure Water DCON-35-OG	**Accepted** Technology has been used by industry.	Development- To minimize waste generation, a system is needed to treat the water so that it can be recycled. Improvement: Automation	Normal implementation needs. Development Cost: $1300K Capital cost: ~$500K Operating cost: ~$1/ft^2
	Shot Blasting (using iron shot) DCON-36-OG	**Accepted** Commercial iron shot blasters are in use at the K-25 site. They are generally effective but leave some hot spots.	Improvement- Automation	A collection system with adequate filtration. Development cost: None Capital cost: ~$50K Operating cost: $0.10-$1/ft^2
	Grit Blasting (using sand, glass beads, metallic beads, etc.) DCON-38-OG	**Accepted** Has been used successfully for many applications in the nuclear industry. Technology is generally effective. Waste would be spent grit, abraded substrate, and removed contaminants in filters and HEPA filters.	Improvement- automation, more durable blast media. Better vacuum system demostration.	A collection system with adequate filtration. Development cost ~$4-10M Capital cost: ~$500K Operating cost: <$2/ft^2
	Centrifuge Cryogenic CO_2 Blasting DCON-39-OG	**Predemonstration** Centrifuge pellet acceleration has been demonstrated in the DOE fusion energy program. Technology is likely successful with essentially infinite decontamination factors. Waste would be filters and HEPA filters filled with removed contaminants and some substrate.	Development - Demonstration of mobile system with high-velocity pellets delivered at a sufficient rate and adequate collection of removed contaminants.	A collection system with adequate filtration plus oxygen-depletion precautions. Development cost: ~$3.4M Capital cost: ~$200K Operating cost: $0.07 - $0.75/ft^2 (200 - 2000 ft^2/hr)
	Ice Blasting DCON-40-OG	**Accepted by Industry** Efficacy of commercial system for this application needs demonstration. Waste would be about 14-18 gallons/hour waste water containing removed contaminants.	Development- automation/robotics, especially for walls, corners, etc.	Normal implementation needs. Capital cost: $100K-$1M Evaporator for Waste water Treatment: ~$60K Operating cost: <$1/hr
	Supercritical CO_2 DCON-41-OG	**Predemonstration** Likely to be effective with nearly infinite decontamination factors. Waste would be removed contaminants and some substrate contained in a cyclone and a HEPA filter.	Development - Investigate the effect of operating parameters on removal rates and removal and collection efficiencies for contaminants. Demonstrate efficacy for contaminants of interest	A collection system with adequate filtration plus oxygen depletion precautions. Development costs: $1-4M Capital cost: $800K - $1300K Operating cost: ~$2/ft^2

Technology Logic
Decontaminatio

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

K-25 Site Problem (from Decommissioning (D&D))

- Enrichment Process Building
- Process Support Building
- Electrical and Electrical Switch Gear
- Pumping Stations
- Laboratory Facilities
- Special Development Facilities
- Administrative Facilities
- Cooling Towers

Problem Area/Constituents

Sheet Metal
Metal Exterior Surfaces
Oil, PCBs, U, Tc, Actinides

Structural Steel
U, Oil, Tc, PCBs, Actinides

Metal Equipment Exterior
U, Oil, Tc, PCBs, Actinides

Copper
Oil

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelements

Decontamination

Alternativ

- Mechanical Substi Surface Removal (fixed and transfer contamination) (cont'd)
- Thermal Substrate Removal (fixed and transfer contamination)

Logic Diagram
tamination

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Mechanical Substrate Surface Removal (fixed and transferrable contamination) (cont'd)	Plastic Pellet Blasting DCON-42-OG	**Accepted** Plastic pellet blasting is a widely used alternate to sand blasting for applications in which it is desired to impart minimal damage to the substrate. Technology should remove smearable, but not fixed contamination. Waste would be spent plastic pellets plus removed contamination.	Development: Develop and demonstrate system for processing waste. Improvement - Minimize blast media erosion to minimize waste; automation/robotics; improved containment of waste and removed contaminants.	A system for processing waste to an acceptable form is needed. Development cost: $5.5M+ Capital cost: ~$50K Operating cost: $0.20 - $2.15/ft^2
	Grinding, Honing, Scraping DCON-43&44-OG	**Accepted** Using hand grinders has been successfully used for small-scale decontamination at K-25. Technology is successful. Waste is removed substrate plus contaminants.	Improvement - A remotely operated system for minimizing worker exposure with a vacuum system for minimizing spread of contamination should be developed.	Normal implementation needs. Development cost: Vacuum system: $200-1000K Remote operation: $1-4M Capital Cost: $150 ($50-500K with vacuum system and remote operation) Operating Cost: ~$0.50/ft^2
	Metal Milling DCON-45-OG	**Conceptual** Milling equipment is commercially available, but no references to its use for decontamination have been found. Waste would be removed substrate and contaminants.	Development - The technology to remotely operate the equipment is needed.	Normal implementation needs. Development Cost: $3-5M Capital Cost: $50K $360K Operating Cost: ~$17.50/ft^2
Thermal Substrate Surface Removal (fixed and transferrable contamination)	Plasma Torch DCON-72-OG	**Evolving Technology** Conceptual - Plasma torches exist commercially to weld and cut materials that have very high melting temperature or require and inert atmosphere. Its efficacy in removing various organic contaminants or to layers of contaminated surface has not been investigated. Wastes would consist of materials used to trap reaction products from the decomposition of organics and spalled surfaces with contaminants.	Science - Laboratory tests are needed to evaluate the efficacy of vaporizing or decomposing organics, determine the decomposition reaction by-products, and suitable trapping materials. Development - Plasma torches having geometries and conditions suitable for decontamination need to be developed along with suitable collection and gas treatment systems.	Normal implementation needs. Development cost: About $3M Capital cost: About $200K Operating cost: $0.01-$1.00/ft^2
	Laser Heating DCON-73-OG	**Demonstration** Currently being evaluated by Air Force as a method for removing organic coatings from metal; current systems are capable of removing 2-mil thick coatings at the rate of 100 ft^2/hr.; waste will be prefilters and HEPA filters filled with contaminants.	Development - Demonstration of decon. capability of existing lasers.	Normal implementation needs. Development costs: $2M + Capital cost: $1-10M/machine Operating cost: ~$1/ft^2

Technology Lo

Decontamin

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
Enrichment Process Building Process Support Building Electrical and Electrical Switch Gear Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Cooling Towers	Sheet Metal **Metal Exterior Surfaces** Oil, PCBs, U, Tc, Actinides Structural Steel U, Oil, Tc, PCBs, Actinides Metal Equipment Exterior U, Oil, Tc, PCBs, Actinides Copper Oil	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Therm Remo (fixed contan (cont.) Surfac (transf contan

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Thermal Substrate Surface Removal (fixed and transferrable contamination) (cont.)	Plasma Surface Cleaning DCON-75-OG	**Pre-demonstration** Plasma surface cleaning by glow discharges is commonly and effectively utilized for cleaning high bonding energy contaminants from surfaces of metals prior to the operation of fusion devices. Technology is expected to be effective for removing deposits from listed substrates, but whether the plasma can follow irregular shapes is uncertain. Wastes would be the vaporized deposits plus filters and HEPA filters from the collection system.	Science - Data on cleaning rates for contaminants and substrates of interest are needed. Development - The capability of plasma generation and cleaning on surfaces of typical contaminated metals and equipment with large surface areas needs to be established.	A collection system with appropriate filters for the vaporized deposits would be needed to use this technology. An electric power supply would be needed. Development cost: About $4M Capital cost: $500K-$1000K Operating cost: $0.50-$2.00/ft^2
Surface Cleaning (transferrable contamination)	High Pressure Water DCON-52-OG	**Accepted** High pressure water blasting has been used very successfully to decontaminate various large and complex surfaces at nuclear power plants. Technique is expected to be effective with a DF of about 50 for loosely adhering contamination. DFs will be higher if chemical cleaning agents are also used. Technique is expected to be ineffective for fixed contamination. Waste is 4 to >100 gpm of contaminated waste water.	Development - To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be reused. Improvement - Remote operation will necessitate the adaptation of the high pressure water and vacuum collection systems to robotic system control.	Normal implementation needs. Development cost: Water treatment system: about $1.2M Remote operation: $3-4M Capital cost: $50K-$75K (about $250K with remote operation) Operating cost: $0.03-$1.00/ft^2
	Sponge Blasting DCON-58-OG	**Accepted** Although the technology is relatively new, it is currently being used by, at least two sites, including a nuclear power plant. Extensive data on decontamination factors are not available, but the aggressive sponges, which are impregnated with abrasives, may be effective for the listed contaminants and substrates. Wastes consist of about 0.01 ft^3 if blasting media and removed contaminants per ft^2 of area decontaminated plus any liquid cleaning agents that may have been added.	Development - To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be recycled and reused in the sponge blasting operation.	Normal implementation needs. Development cost: About $1.2M Capital Cost: Sponge blasting system: About $20K (with blasting media wash unit) Glove box: <$50K Work room: About $250K Operating cost: About $2/ft^2

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

Enrichment Process Building

Process Support Building

Electrical and Electrical Switch Gear

Pumping Stations

Laboratory Facilities

Special Development Facilities

Administrative Facilities

Cooling Towers

Sheet Metal
Metal Exterior Surfaces
Oil, PCBs, U, Tc, Actinides

Structural Steel
U, Oil, Tc, PCBs, Actinides

Metal Equipment Exterior
U, Oil, Tc, PCBs, Actinides

Copper
Oil

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Decontamination

Surface Cleanin
(transferrable contamination)
(cont.)

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Surface Cleaning (transferrable contamination) (cont.)	Compressed Air Cryogenic CO_2 DCON-51-OG	**Demonstration** This technology is commercially available. It has been used at nuclear reactor sites to decontaminate hand tools and some equipment. The efficacy of this technology for removing the listed contaminants from the listed substrates has not been demonstrated. Wastes would be HEPA filters filled with the removed contaminants.	Development - Demonstration of the efficacy of this technology for the listed contaminants and substrates	Design and construction of a vacuum waste-handling system with HEPA filters to handle the vaporized CO_2 containing the removed contaminants are needed to use this technology. A vacuum collection system with well designed nozzles might permit in situ decontamination of assembled equipment and structures. Development costs: $750-$3000K Capital cost: CO_2 system: About $200K Operating cost: $0.50-$10/ft^2
	Superheated Water DCON-53-OG	**Accepted** Technology is available and has been used by industry. Technology should be effective except for fixed insoluble contamination. Waste will be 0.4 to 2.0 gpm wastewater containing removed contaminants.	Development - To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be reused. Improvement - Remote operation will necessitate the adaptation of the superheated and vacuum collection systems to robotic system control.	Normal implementation needs. Development cost: Water treatment system: about $1.2M Remote operation: $3-4M Capital cost: About $175K (about $250K with remote operation) Operating cost: $0.03-$1.00ft^2
	Hot Water DCON-54-OG	**Accepted** Flushing with hot water is often used following scrubbing. The technique is not effective on fixed insoluble contamination. The waste generated is the contaminated water from the flushing operation.	Improvement - To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be recycled and reused in the hot water cleaning operation.	A water treatment system is needed to minimize liquid wastes from this technology. Development cost: About $1.2M Capital cost: <$5K Operating cost: <$1/ft^2
	Steam DCON-55-OG	**Accepted** The technique has proven useful, especially on complex shapes and large surfaces. Technology should be effective except for fixed insoluble contamination. Waste will be 0.4 to 2.0 gpm wastewater containing removed contaminants.	Development - To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be reused. Improvement - Remote operation will necessitate the adaptation of the steam and vacuum collection systems to robotic system control.	Normal implementation needs. Development cost: Water treatment system: about $1.2M Remote operation: $3-4M Capital cost: $50K-$75K (about $250K with remote operation) Operating cost: $0.03-$1.00ft^2

Technology Lo

Decontamin

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

Enrichment Process Building

Process Support Building

Electrical and Electrical Switch Gear

Pumping Stations

Laboratory Facilities

Special Development Facilities

Administrative Facilities

Cooling Towers

Problem Area/Constituents

Sheet Metal
Metal Exterior Surfaces
Oil, PCBs, U, Tc, Actinides

Structural Steel
U, Oil, Tc, PCBs, Actinides

Metal Equipment Exterior
U, Oil, Tc, PCBs, Actinides

Copper
Oil

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelements

Decontamination

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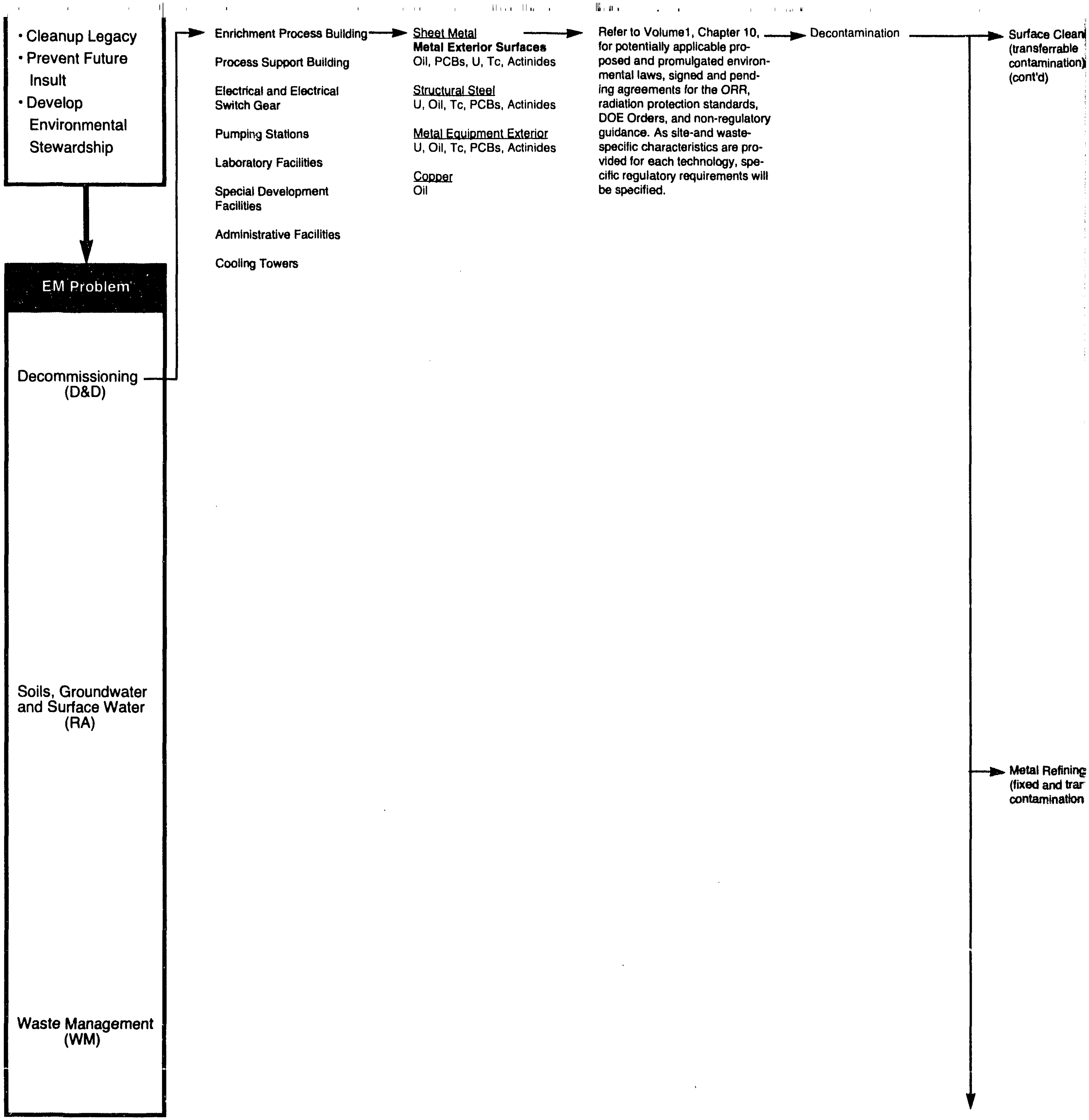
	Technologies	Status	Science/Technology Needs	Implementation Needs
Surface Cleaning (transferrable contamination) (cont'd)	Brushing DCON-56&57-OG	**Accepted** Manual brushing has been used to remove loose contamination for years. Demonstration - Remote power brushing was used to clean the interior of plutonium-contaminated pipe at Rocky Flats to shiny metal. Since most of the listed contaminants are not expected to be in loose form, brushing is not expected to be effective. Wastes consist of HEPA filters on the vacuum cleaner used to pick up the removed contaminants.	Development - A test to demonstrate that this technique will work is needed before a large capital investment is made for a power brushing system at K-25.	Normal implementation needs. Manual brushing Capital costs: <$10K Operating costs: >$1/ft^2 Power system Development costs: $200K-$1000K Capital costs: About $50K ($250K with remote operation) Operating cost: >>$10/ft^2
	Hot Air DCON-59-OG	**Evolving Technology** Conceptual - Air stripping technology is well known for removing volatiles from liquids, but there is no known use of this technology to decontaminate metals. The technology may be effective in removing oil, PCBs, and perhaps Tc, but probably none of the other listed contaminants from the listed substrates. Wastes would be spent chemicals from gas treatment system containing any removed contaminants.	Development - Effective removal of the listed contaminants from metals should be demonstrated; an effective off-gas treatment system needs to be designed and tested.	An off-gas collection and treatment system is needed for this technology. Development costs: $1-5M Capital cost: About $200K Operating cost: $2-20/ft^2
	Dry Heat (Roasting) DCON-60-OG	**Demonstration** Although dry heat (roasting) is an accepted industrial process, its efficacy for removing oil and PCBs from the listed substrates needs to be demonstrated. Technology has a moderate probability of success for oil and PCBs, some probability of success for Tc, and little chance of success for the other contaminants. Waste would be removed oils and PCBs (and, possibly Tc). (Oils might be combusted.)	Development - Demonstration of the efficacy of the process; development and demonstration of an off-gas treatment system.	An off-gas collection and treatment system would be needed to use this technology. Development cost: $1-4M Capital cost: About $250K with collection and treatment system Operating cost: $2-20/ft^2
	Solvent washing DCON-61&62-OG	**Evolving Technology** Conceptual - Solvent degreasing was used successfully at K-25, but its use was stopped to avoid exposing workers and the environment to the hazardous solvents. The effectiveness of less hazardous solvents would have to be demonstrated. Wastes would be the solvents containing any removed contaminants.	Development - Solvents that are less damaging to the environment need to be identified and their effectiveness demonstrated.	Requires removal and disassembly of contaminated equipment and size reduction to roughly 2 tons/piece for processing. Spent solvents would have to be "burned" at the TSCA incinerator. Development costs: $1-4.5M Capital cost: About $400K Operating cost: About $0.01/lb



• Cleanup Legacy
• Prevent Future Insult
• Develop Environmental Stewardship
EM Problem
Decommissioning (D&D)
Soils, Groundwater and Surface Water (RA)
Waste Management (WM)
Enrichment Process Building
Process Support Building
Electrical and Electrical Switch Gear
Pumping Stations
Laboratory Facilities
Special Development Facilities
Administrative Facilities
Cooling Towers
Sheet Metal
Metal Exterior Surfaces
Oil, PCBs, U, Tc, Actinides
Structural Steel
U, Oil, Tc, PCBs, Actinides
Metal Equipment Exterior
U, Oil, Tc, PCBs, Actinides
Copper
Oil
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Decontamination
Surface Clean
(transferrable contamination)
(cont'd)
Metal Refining
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Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Surface Cleaning (transferrable contamination) (cont'd)	Strippable Coatings DCON-63-OG	**Accepted** Technology has been used for decontamination applications involving hazardous and radioactive contaminants. Decontamination factors of one to several hundred can be expected with two applications. Waste is a solid polymer (1mm x surface area decontaminated) containing the removed contaminants.	None	Normal implementation requirements. Capital cost: <$10K Operating cost: \$1.00-\$1.40/ft^2
	Vacuuming DCON-64-OG	**Accepted** Vacuum cleaners have long been used to clean up loose contamination of the GDPs. Since the listed contaminants may be in loose form, this technique could be effective in cleaning exterior equipment surfaces, structural steel, etc. The waste is prefilters and HEPA filters filled with the contaminants and other materials that are removed by the vacuum.	None	Normal implementation needs. Capital cost: <$10K Operating cost: <\$1/ft^2
	Ultrasonic Cleaning DCON-66-OG	**Accepted** Ultrasonic cleaning has been used for may years in the private sector and in government installations for removing surface contamination from relatively small metal parts which can fit into an ultrasonic bath. Wastes would be spent ultrasonic baths containing any removed contaminants.	Development - Definition of acceptable cleaning liquids which (1) are not hazardous, (2) can be separated from the contaminants, and (3) can be reused to minimize secondary wastes. Improvement - More aggressive cleaning action.	Requires removal, disassembly, and size reduction of contaminated equipment. Development cost: $1M Capital cost: $10K-$100K Operating cost: \$2-\$10/ft^2 or more
Metal Refining (fixed and transferrable contamination)	Smelt Purification DCON-31-OG	**Demonstration** Performed by many investigators on a lab scale and by some on a large scale. U removed to 0.01-4ppm. Tc is not removed. Wastes are slags, scrubber solutions, chemical trap materials, and HEPA filters.	Science - Demonstrate fluxing agent for removing Tc. Development - Demonstrate Tc removal on a larger scale.	Requires removal, disassembly, and size reduction of equipment. Partial decontamination by another technique may be needed before smelting. Standard induction or arc furnace with off-gas treatment system is needed. *De minimus* limits are needed to release the material. Development cost: $3-5M Operating plus capital cost is about $1/lb.

Technology Lo

Decontamin

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Building Process Support Building Electrical and Electrical Switch Gear Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Cooling Towers	Sheet Metal **Metal Exterior Surfaces** Oil, PCBs, U, Tc, Actinides Structural Steel U, Oil, Tc, PCBs, Actinides Metal Equipment Exterior U, Oil, Tc, PCBs, Actinides Copper Oil	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Metal (fixed contai (cont.) Chem (fixed contai

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

ogic Diagram
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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Metal Refining (fixed and transferrable contamination) (cont.)	Electrorefining DCON-32-OG	**Pre-demonstration** Not demonstrated on a large scale for the decontamination of radioactive materials. Tc plates out on the cathode. Technology is likely to be effective for the listed contaminants and substrates. Waste would be solid mixed waste from assumed treatment of electrolyte solutions for recycle.	Development - Demonstrate techniques to (1) prevent Tc from plating out with Ni and Al; (2) reduce U contamination in refined Al; and (3) recycle electrolyte solutions.	Smelter is needed to cast anodes. Development cost: About $3M Capital cost: About $200M (10M lb/yr capacity) Operating cost: About $6/lb
	Leach/electrowinning DCON-34-OG	**Pre-demonstration** The method is similar to electrorefining except the metal is first dissolved into solution rather than formed into anodes. Although this process is a well established commercial process for producing nickel from ore, it has not been demonstrated on a large scale for purifying metals contaminated with radioactivity. SEG has purified nickel to <1 Bq/g of Tc on a small scale. The Tc must be removed from the electrolytic solutions by ion exchange or some other method. Recycle of electrolytic solutions will result in a solid mixed waste bearing the contaminants and traces of the purified metal amounting to roughly 2% by weight of the metal purified.	Development - Demonstrate techniques to recycle the electrolytic solutions.	A de minimus standard is needed to permit sale of the purified metal. Development costs: About $500K Capital cost: $200M (10M lb/yr plant) Operating cost: $3.80/lb
Chemical Surface Cleaning (fixed and transferrable contamination)	Chemical Foams DCON-8-OG	**Demonstration** Effectiveness for listed contaminants and substrates has not been demonstrated. Wastes would be contaminated sulfonated detergents, synthetic wetting agents, and coupling agents.	Science - A fundamental understanding of bubble dimensions and volume swell factor is needed. Development-Demonstration of effective in situ decontamination of listed contaminants on listed substrates with adequate control of bubble dimensions and volume swell factor.	Normal implementation needs. Development cost: $1-4M Capital cost: <$50K Operating cost: $0.50-$2.00/ft²
	Chemical Gels DCON-9-OG	**Demonstration** Gel is a carrier of chemical decontamination agents, not an agent itself. Expected to be effective only for smearable contamination. Wastes would be carboxymethylcellulose gelling agent, aluminum nitrate chelating agent, wash water, acidic chemical agent (possibly nitric-hydrofluoric-oxalic acid), and the removed contaminants. Wastes are reportedly 4-5 times less compared to chemical solutions.	Development: Complex gel formulation with a number of compounds may be required. Depending on its objective, laboratory optimization will be necessary.	Normal implementation needs: Development cost: $1-4M Capital cost: <$50K Operating cost: $0.50-$2.00/ft²

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EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

Enrichment Process Building

Process Support Building

Electrical and Electrical Switch Gear

Pumping Stations

Laboratory Facilities

Special Development Facilities

Administrative Facilities

Cooling Towers

Problem Area/Constituents

Sheet Metal
Metal Exterior Surfaces
Oil, PCBs, U, Tc, Actinides

Structural Steel
U, Oil, Tc, PCBs, Actinides

Metal Equipment Exterior
U, Oil, Tc, PCBs, Actinides

Copper
Oil

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

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Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Chemical Surface Cleaning (fixed and transferrable contamination) (cont'd)	Organic Acid Treatments DCON-10-OG	**Demonstration** The BNFL citric acid decontamination process is currently used by BNFL at the Capenhurst gaseous diffusion plant for large scale, successful decontamination of wrought aluminum. DF of 300 for U alpha and 40 for Tc beta are reported (11.1 Bq/g alpha, 0.04 Bq/g beta). A citric acid process followed by a sulfuric acid process is used. Wastes include citric and sulfuric acids containing uranium and other metal ions and ion exchange media containing the metals. Uranium is difficult to precipitate.	Development: Development is needed on a pilot plant scale for waste treatments (ion exchange columns) to verify that we can meet our regulatory requirements and to evaluate the effectiveness on the metals used by American gaseous diffusion plants, which differ from the British plants.	Waste treatment plant. Development cost: $400-1000K (Rough estimate) Capital cost: $4-10 million (Rough estimate) Operating cost: ~$300/metric ton (BNFL Estimate) Existing facilities at K-25 may possibly be adapted to this process .
	Inorganic Acid Treatments DCON-12-OG	**Accepted** Decontamination with nitric acid has been used for cleaning converters and other large items at K-25 for many years. Sulfuric acid is used less often, notably to dissolve nickel plating prior to removing contaminants at the nickel-steel interface. The inorganic acids are concentrated, with concurrent corrosion. DFs are in the 100 range. Wastes consist of large quantities of corrosive wastes containing the removed contaminants and require treatment and disposal as mixed waste.	Development- Necessary to adapt modifications to the system (scrubbers, filters, treatment for nitrates and heavy metals) in order to meet regulatory requirements. Science/Development- Possible development of the HNO3/HF decontamination method, with or without ultrasonic agitation.	Normal implementation needs. Development cost: $400-1000K (Rough estimate) Capital cost: <$4-10 million (Rough estimate) Although existing facilities may be adaptable to the acid cleaning process, a treatment facility for corrosive nitrate wastes will be required. Operating cost: Similar to the other organic and inorganic treatment systems.
	Fluoboric Acid Treatment DCON-11-OG	**Demonstration** The technology was specifically designed for D&D (Chernobyl application) and is likely to be highly effective on most metal and metallic oxide surfaces. it removes the outer layer in a controlled and effective manner. The acid can be electrolytically regenerated and recycled with radioactive waste plated out at the cathode and solidified in cement. Final quantity of cement-solidified waste is 20-50 grams/m^2 of decontamination surface. Other waste treatment options are possible.	Development: Although the method has seen application at Chernobyl with good results, development work is needed to test applicability to USGDP equipment.	Normal implementation needs. Development cost: $400-1000K (Rough estimate) Capital cost: $800K (1990 estimate for equipment only for 5T/day capacity of metal) $4-10 million (Rough estimate including engineering and facilities) Operating cost: ~$300/metric ton

Technology Lo

Decontamin

EM Goals

- Cleanup Legacy
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EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

Enrichment Process Building

Process Support Building

Electrical and Electrical Switch Gear

Pumping Stations

Laboratory Facilities

Special Development Facilities

Administrative Facilitieo

Cooling Towers

Problem Area/Constituents

Sheet Metal
Metal Exterior Surfaces
Oil, PCBs, U, Tc, Actinides

Structural Steel
U, Oil, Tc, PCBs, Actinides

Metal Equipment Exterior
U, Oil, Tc, PCBs, Actinides

Copper
Oil

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelements

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Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Chemical Surface Cleaning (fixed and transferrable contamination) (cont'd)	Caustic Treatments DCON-13-OG	**Accepted** Decontamination of surface smearable contamination using caustic chemicals (principally soap and water) has been used at K-25 for many years. Since many of the listed contaminants are expected to be fixed, caustic scrubbing is expected to only partially decontaminate the contaminated surfaces. Wastes would consist of used caustic solution containing the removed contaminants.	None	A waste treatment plant is needed to treat the waste-water resulting from the decontamination operation. Capital cost: <$10K Operating cost: >$1/ft^2
	Electropolishing DCON-15-OG	**Demonstration** Electropolishing is widely used to remove radioactive contaminants from metal surfaces but has not been demonstrated at the USGDPs. The method is very likely to be successful, since it results in removing a small depth of the surface. Acidic solutions will be generated which must be recycled, perhaps by ion exchange methods.	Development: Some development work is required to apply the method to USGDP applications, and to recycle electrolytic solutions	Normal implementation needs. Development cost: $400-1000K (Rough estimate) Capital cost: not available (can be constructed in modules easily) Operating cost: more expensive than most other methods since items must be subjected to electric current.
	REDOX Treatments DCON-14-OG	Demonstration - REDOX treatments include Citrox (a mixture of oxalic and citric acids), low oxidation-state metal ion process, and cerium solutions in acid. REDOX treatments have been demonstrated for nuclear power plant decontamination, but not for the contaminants of interest. DFs of 10-100 can be expected based on experience in nuclear power plants. With recycle, waste is spent ion exchange media containing removed contaminants. With neutralization and evaporation, waste is a solid mixed waste containing the removed contaminants and chemicals from the REDOX reagents.	Development - All REDOX techniques will require bench-scale testing and small-scale demonstrations to determine their usefulness for decontamination of gaseous diffusion equipment.	A system for treating the REDOX reagents to permit recycling these reagents will be needed to use this technology. Development costs: $2.5-$5.0M Capital costs: >$1M Operating cost: $0.10-$1/ft^2

Technology Logi(

Decontaminatio

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternati
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Building Process Support Building Electrical and Electrical Switch Gear Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Cooling Towers	Sheet Metal **Metal Exterior Surfaces** Oil, PCBs, U, Tc, Actinides Structural Steel U, Oil, Tc, PCBs, Actinides Metal Equipment Exterior U, Oil, Tc, PCBs, Actinides Copper Oil	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Chemical Surfa((fixed and trans(contamination) (cont'd) Bulk Decontai Methods

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

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Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Chemical Surface Cleaning (fixed and transferrable contamination) (cont'd)	Biological DCON-17-OG	**Evolving Technology** Pre-conceptual - The knowledge base exists for biological treatments of various contaminants; however, there is no data base for application of the technology for surface decontamination. This technology is quite likely to be successful for oil and PCBs. It could be successful for U, Tc, actinides, and chromates, but these contaminants would remain in the bacterial sludge. The waste generated would be the contaminated layer of microbes removed from the treated surface.	Science - Literature study and bench-scale tests of microbes on U, Tc, actinides, and chromates. Development - Develop methods for applying a layer of microbes, supplying needed nutrients, and removing the microbe layer from the decontaminated item.	Facilities for cultivating the bacteria and disposing of the bacterial sludge would be needed. Development cost: $300K-$600K Capital cost: About $200,000 Operating cost: $0.10-$3.00+/ft^2
	Laser Activated Chemistry DCON-18-OG	**Evolving Technology** Acceleration of reaction rates for selected reactions is proven. Small scale decon has been demonstrated. Waste would be prefilters and HEPA filters filled with removed contaminants.	Development - Demonstration of vacuum systems capable of collecting removed contaminants.	Normal implementation needs. Development costs: $2M + Capital cost: $1-10M/machine Operating cost: Unknown
	UV/Ozone DCON-19-OG	**Pre-demonstration** This method has been used by the semiconductor industry to decompose organic contaminant molecules to volatile molecules, such as CO2, H2O, N2. Only contaminants that will dissociate and react with atomic oxygen to form volatile molecules are removed.	Science: Using commercial UV/ozone hardware, laboratory scale experiments should be conducted to establish cleaning rates on removing organic contaminants from different substrates and to develop necessary techniques to handle the waste generated. Subsequently, the equipment should be developed with a capability of performing robotic, remote, and automatic operation with computer control.	Normal implementation needs. Development cost: ~$1 million ($200K equipment, $800K staff) Demonstration activities: ~$2 million ($500K equipment, $1.5 million staff) Capital cost: Potentially much of the equipment used in the demonstration could be used in the production phase. Uncertain additional capital costs. Operating cost: ~$1/ft^2 (rough estimate)
Bulk Decontamination Methods	Catalytic Extraction Process DCON-6-OG	**Pre-demonstration** Has not been used to smelt scrap bearing radioactivity. Likely to reduce mild steel to 0.01-4ppm U. Tc is not removed. Wastes would be about 50 lb of slag containing removed contamination per ton of scrap metal processed plus contaminated scrubber solution or chemical trapping materials.	Science - Method for removing Tc. Development - Demonstrate Tc removal.	"Off-the-shelf" induction or gas furnace with off-gas treatment. Development cost: $3-5M Capital cost: About $16M Operating cost: $0.93/lb

Technology Lo

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EM Goals

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EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Manageme t (WM)

K-25 Site Problem

Enrichment Process Building

Process Support Building

Pumping Stations

Laboratory Facilities

Special Development Facilities

Administrative Facilities

Cooling Towers

Problem Area/Constituents

Concrete
U
Tc
Actinides
Chromate
Oil
PCB

Reference Requirements

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Subelements

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Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Mechanical Substrate Surface Removal	Ultra High-Pressure Water DCON-35-OG	**Accepted** Technology has been used by industry. Should work on concrete at GDPs. Unless a recycle system is developed, waste would be 3 - 5 gal water per ft^2 concrete cleaned containing ~0.01 ft^3 concrete residue plus the contaminants removed.	Development- To minimize waste generation, a system is needed to treat the water so that it can be recycled. Improvement: Automation	Normal implementation needs. Development Cost: $1300K Capital cost: ~$500K Operating cost: ~$1+/$ft^2$
	Shot Blasting (using iron shot) DCON-36-OG	**Accepted** Commercial iron shot blasters are in use at the K-25 site. They are generally effective but leave some hot spots. Waste is ~0.01 ft^3 removed concrete (1/16" cut) containing removed contaminants plus 0.05lb spent shot per ft^2 of concrete decontaminated.	Improvement- Automation	Normal implementation needs Development cost: None Capital cost: ~$50K Operating cost: ~$0.03/ft^2
	Mechanical Scabblers DCON-37-OG	**Accepted** Mechanical scabblers are used for concrete decontamination at ORGDP and elsewhere. They are generally effective, but leave some hot spots. Waste is ~0.01 ft^3 removed concrete (1/16" cut) containing removed contaminants per ft^2 of concrete decontaminated	Improvement - Automation	Normal implementation needs Development cost: None Capital cost: ~$500K Operating cost: < $1/$ft^2$ (More than shot blasting)
	Grit Blasting (using sand, glass beads, metallic beads, etc.) DCON-38-OG	**Accepted** Has been used successfully for many applications in the nuclear industry. Technology is generally effective. Waste is ~0.01 ft^3 removed concrete (1/16" cut) containing removed contaminants per ft^2 of concrete decontaminated plus spent grit.	Improvement- automation, especially for walls and ceilings.	Normal implementation needs Development cost: None Capital cost: ~$500K Operating cost: $1/$ft^2$
	Centrifuge Cryogenic CO_2 Blasting DCON-39-OG	**Predemonstration** Centrifuge pellet acceleration has been demonstrated in the DOE fusion energy program. Technology is likely successful with essentially infinite decontamination factors. Waste would be filters and HEPA filters filled with removed concrete dust and contaminants.	Development-Demonstration of mobile system with high-velocity pellets delivered at a sufficient rate and adequate collection of removed contaminants.	Normal implementation needs plus oxygen-depletion precautions. Development cost: ~$3.4M Capital cost: ~$200K Operating cost: $0.07 - $0.75/$ft^2$ (200 - 2000 ft^2/hr)
	Ice Blasting DCON-40-OG	**Accepted by Industry** Efficacy of commercial system for this application needs demonstration at K-25. Waste would be about 14 to 18 gallons per hour waste water containing removed contaminants.	Development- automation/robotics, especially for walls, corners, etc.	Normal implementation needs. Capital cost: $100K-$1M Operating cost: <$1/$ft^2$

Technology Log

Decontamina

EM Goals

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EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alte
Enrichment Process Building Process Support Building Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Cooling Towers	Concrete U Tc Actinides Chromate Oil PCB	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Mechanic Surface F (cont.)

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Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Mechanical Substrate Surface Removal (cont.)	Supercritical CO_2 Blasting DCON-41-OG	**Predemonstration** Likely to be effective with nearly infinite decontamination factors. Waste would be removed concrete and contaminants contained in a cyclone and a HEPA filter.	Development - Investigate the effect of operating parameters on removal rates and removal and collection efficiencies for contaminants. Demonstrate efficacy for contaminants of interest	Normal implementation needs plus oxygen depletion precautions. Development costs: $1-4M Capital cost: $500K - $1000K Operating cost: $1+/ft²
	Plastic Pellet Blasting DCON-42-OG	**Accepted** Plastic pellet blasting is a widely used alternate to sand blasting for applications in which it is desired to impart minimal damage to the substrate. Technology should remove smearable, but not fixed contamination from concrete. Waste would be spent plastic pellets plus removed contamination.	Development: Develop and demonstrate system for processing waste. Improvement - Minimize blast media erosion to minimize waste; automation/robotics, especially for walls, etc.; improve containment of waste and removed contaminants.	A system for processing waste to an acceptable form is needed. Development cost: $6.5M+ Capital cost: ~$50K Operating cost: $0.20 - $2.15/ft²
	Grinding, Honing, Scraping DCON-43&44-OG	**Accepted** Hand grinders have been successfully used for small-scale decontamination at K-25. Technology is successful. Waste is removed concrete plus contaminants and spent emery paper or dust.	Improvement - A remotely operated system for minimizing worker exposure with a vacuum system for minimizing spread of contamination should be developed.	Normal implementation needs. Development cost: Vacuum system: $200-1000K Remote operation: $1-4M Capital Cost: $150 ($50-500K with vacuum system and remote operation) Operating Cost: ~$0.50/ft²
	Concrete Milling DCON-47-OG	**Conceptual** Concrete milling equipment is commercially available and used on roads, but no references to its use for decontamination have been found. It is only suitable for use on large horizontal surfaces. Waste would be removed concrete (6-25mm) and contaminants.	Development - The technology to remotely operate the equipment is needed.	Normal implementation needs. Development cost: $3-5M Capital cost: $50K-$363K Operating cost: $0.02 - $0.14/ft²
	Explosive DCON-48-OG	**Demonstration** Explosive scrabbling has been used at nuclear reactors, but has not been demonstrated on the buildings at K-25. Technology is expected to be successful. Waste would be rubble from removing 3-4" concrete plus removed contaminants.	Development - Safety concerns need to be resolved. Better containment of dust and better assurance of prevention of structural damage to the building is needed. Improvement - Better methods of applying the explosives and more uniform detonations that remove less concrete are needed.	A certified blasting technician and covers to contain the dust will be needed along with an air evacuation system with filters Development cost: $1-4M Capital cost: <$50K Operating cost: About $5/ft²

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Decontamin

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Building →	Concrete U Tc Actinides Chromate Oil PCB →	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified. →	Decontamination →	Ther Rem
	Process Support Building				
	Pumping Stations				
	Laboratory Facilities				
	Special Development Facilities				
	Administrative Facilities				
	Cooling Towers				

EM Problem

- Decommissioning (D&D) → Enrichment Process Building …
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

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Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Thermal Substrate Surface Removal	Microwave Scrubbing DCON-71-OG	**Predemonstration** In FY 91 ORNL demonstrated reliable removal of noncontaminated concrete surfaces using a stationary microwave device. A mobile device is under development. Since microwave scrabbling removes the contaminated concrete surface, the decontamination efficiency should be essentially 100% unless the contamination has diffused deep into the concrete. The waste generated is concrete rubble with particle diameters lying primarily in the range of 1 to 10 mm plus the contaminants. For a removal depth of 10 mm, 0.03 ft^3 of concrete rubble is generated per ft^2 of concrete decontaminated.	Development - The development and testing of a mobile prototype microwave concrete removal machine needs to be completed.	Normal implementation needs. Development cost: $2.5M Capital cost: About $250K Operating cost: $0.01-$0.73/ft^2
	Plasma Torch DCON-72-OG	**Evolving Technology** Conceptual - Plasma torches exist commercially to weld and cut materials that have very high melting temperatures or require an inert atmosphere. Its efficacy in removing various organic contaminants or to spall off layers of contaminated concrete has not been investigated. Wastes would consist of materials used to trap reaction products from the decomposition of organics and spalled concrete with contaminants.	Science - Laboratory tests are needed to evaluate the efficacy of vaporizing or decomposing organics, determine the decomposition reaction by-products, and suitable trapping materials. Laboratory tests of thermal stress-induced spalling of concrete are also needed. Computer modeling of plasma-surface interactions and heat transfer in concrete are needed. Development - Plasma torches having geometries and conditions suitable for decontamination need to be developed along with suitable collection and gas treatment systems.	Normal implementation needs. Development cost: About $3M Capital cost: About $200K Operating cost: $0.01-$1.00/ft^2
	Flashlamp Cleaning DCON-77-OG	**Evolving Technology** Conceptual - Flashlamp systems are being used to clean organic contamination from artwork, ship hulls, and precious metals. Hanford Westinghouse is conducting laboratory tests of xenon flashlamp systems for removing radionuclide contamination. Efficacy for listed contaminants on concrete is unknown. Wastes would be only the contaminants removed from the concrete contained in pre-filters and HEPA filters.	Science - Existing flashlamps should be tested on a small scale for removing the listed contaminants from concrete. Development - A moderate-scale demonstration of flashlamp decontamination of concrete with the associated vacuum collection system is needed.	A vacuum collection system would be needed to use this technology. Development cost: $1-4M Capital cost: $100K-$150K Operating cost: <$1/$ft^2$

Technology Logi

Decontaminati

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

Enrichment Process Building

Process Support Building

Pumping Stations

Laboratory Facilities

Special Development Facilities

Administrative Facilities

Cooling Towers

Problem Area/Constituents

Concrete
U
Tc
Actinides
Chromate
Oil
PCB

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelements

Decontamination

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Surface Cle

Logic Diagram
tamination

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Surface Cleaning	High-Pressure Water DCON-52-OG	**Accepted** High pressure water blasting has been used very successfully to decontaminate various large and complex surfaces at nuclear power plants. Technique is expected to be effective with a DF of about 50 for loosely adhering contamination on concrete. DFs will be higher if chemical cleaning agents are also used. Technique is expected to be ineffective for fixed contamination on concrete. Waste is 4 to >100 gpm of contaminated waste water.	Development - To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be reused. Improvement - Remote operation will necessitate the adaptation of the high pressure water and vacuum collection systems to robotic system control.	Normal implementation needs. Development cost: Water treatment system: About $1.2M Remote operation: $3-4M Capital cost: $50K-$75K (about $250K with remote operation) Operating cost: $0.03-$1.00/ft^2
	Superheated Water DCON-53-OG	**Accepted** - Technology is available and has been used by industry. Technology should be effective except for fixed insoluble contamination or contamination that has soaked into the concrete. On finished concrete, technology may drive contaminants deeper into substrate. Waste will be 0.4 to 2.0 gpm wastewater containing removed contaminants.	Development - To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be reused. Improvement - Remote operation will necessitate the adaptation of the superheated water and vacuum collection systems to robotic system control.	Normal implementation needs. Development cost: Water treatment system: About $1.2M Remote operation: $3-4M Capital cost: About $175K (about $250K with remote operation) Operating cost: $0.03-$1.00/ft^2
	Hot Water DCON-54-OG	**Accepted** Flushing with hot water is often used following scrubbing, especially on floors. The technique is not effective on fixed insoluble contamination. On finished concrete, technology may drive contaminants deeper into substrate. The waste generated is the contaminated water from the flushing operation.	Improvement - To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be recycled and reused in the hot water cleaning operation.	A water treatment system is needed to minimize liquid wastes from this technology. Development cost: About $1.2M Capital cost: <$5K Operating cost: <$1/ft^2
	Steam DCON-55-OG	**Accepted** - The technique has proven useful, especially on complex shapes and large surfaces. Technology should be effective except for fixed insoluble contamination or contamination that has soaked into the concrete. On finished concrete, technology may drive contaminants deeper into substrate. Waste will be 0.4 to 2.0 gpm wastewater containing removed contaminants.	Development - To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be reused. Improvement - Remote operation will necessitate the adaptation of the steam and vacuum collection systems to robotic system control.	Normal implementation needs. Development cost: Water treatment system: About $1.2M Remote operation: $3-4M Capital cost: $50K-$75K (about $250K with remote operation) Operating cost: $0.03-$1.00/ft^2
	Compressed Air Cryogenic CO_2 Blasting DCON-51-OG	**Demonstration** This technology is commercially available. It has been used at nuclear reactor sites to decontaminate hand tools and some equipment. The efficacy of this technology for removing the listed contaminants from concrete has not been demonstrated and is doubtful. Wastes would be HEPA filters filled with the removed contaminants.	None	Design and construction of a vacuum waste-handling system with HEPA filters to handle the vaporized CO_2 containing the removed contaminants. Capital cost: About $200,000 Operating cost: $2-20/ft^2

Technology Lo

Decontamin

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Building Process Support Building Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Cooling Towers	Concrete U Tc Actinides Chromate Oil PCB	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Surf (con

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

.ogic Diagram
amination

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Surface Cleaning (cont.)	Hand and Automated Brushing DCON-56&57-OG	**Accepted** Manual brushing has been used to remove loose contamination for years. Demonstration - Remote power brushing was used to clean the interior of plutonium-contaminated pipe at Rocky Flats to shiny metal, but has not been used on concrete. Since most of the listed contaminants are not expected to be in loose form, brushing is not expected to be effective. Wastes consist of HEPA filters on the vacuum cleaner used to pick up the removed contaminants.	Development - A test to demonstrate that this technique will work for the listed contaminants on concrete is needed before a large capital investment is made for a power brushing system at K-25.	Normal implementation needs. Manual brushing Capital costs: <$10K Operating costs: >$1/ft² Power system Development costs: $200K-$1000K Capital costs: About $50K ($250K with remote operation) Operating cost: >>$10/ft²
	Hot Air Stripping DCON-59-OG	**Evolving Technology** Conceptual - Air stripping technology is well known for removing volatiles from liquids, but there is no known use of this technology to decontaminate concrete. This technology is not expected to be effective in removing the listed contaminants from concrete. The only chance for success would be with oils and, perhaps, PCBs and technetium. Wastes would be spent chemicals from the gas treatment system containing any removed contaminants.	Development - Effective removal of the listed contaminants from concrete should be demonstrated; an off-gas treatment system needs to be designed and tested.	Normal implementation needs. Development cost: $1-5M Capital cost: About $200K Operating cost: $2-20/ft²
	Dry Heat (roasting) DCON-60-OG	**Demonstration** Although dry heat (roasting) is an accepted industrial process, its efficacy for removing oil and PCBs from concrete using either flame from a salamander blown across concrete in situ or roasting of concrete chunks needs to be demonstrated. Technology has a moderate probability of success for oil and PCBs, some probability of success for Tc, and little chance of success for the other contaminants on concrete. Waste would be removed oils and PCBs (U and, possibly, Tc). (Oils might be combusted.)	Development - Demonstration of the efficacy of the process; development and demonstration of an off-gas treatment system.	An off-gas collection and treatment system would be needed to use this technology. Development cost: $1-4M Capital cost: About $250K with collection and treatment system Operating cost: $2-20/ft²

Technology Logic
Decontamination

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternatives
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Building Process Support Building Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Cooling Towers	Concrete U Tc Actinides Chromate Oil PCB	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Surface Cleaning (cont'd)

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram
tamination

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Surface Cleaning (cont'd)	Vacuum Cleaning DCON-64-OG	**Accepted** Vacuum cleaners have long been used to clean up loose contamination at the GDPs. Since little of the listed contaminants are expected to be in loose form, this technique is not expected to be effective in cleaning concrete floors at ORGDP. The waste is a HEPA filter filled with the contaminants and other materials that are removed by the vacuum.	None	Normal implementation needs. Capital cost: <$10K Operating cost: >$1/ft²
	Solvent Washing DCON-61&62-OG	**Conceptual** Solvent cleaning of small items has been used at K-25, and the cleaning of larger areas has been demonstrated at Hanford. The use of solvent cleaning has been stopped at both sites to avoid exposing workers and the environment to the hazardous solvents. Other solvents may be available, but their effectiveness would have to be demonstrated. This method would only be partially effective on smearable contamination. Waste would be spent solvent containing contaminants plus a trace of concrete.	Development - Solvents that are less harmful to health and the environment need to be identified and demonstrated.	Solvent off-gas collection and treatment system would be needed. Development cost: $1-4.5M Capital cost: <$100K Operating cost: About $1/ft²
	Strippable Coatings DCON-63-OG	**Accepted** Technology has been used for decontamination applications involving hazardous and radioactive contaminants. Decontamination factors of one to several hundred can be expected with two applications. Waste is a solid polymer (volume = 1 mm x surface area decontaminated) containing the removed contaminants.	Improvement - Develop coatings with lower material costs and greater ease of application.	Normal implementation needs. Capital costs: Negligible Operating cost: $1 to $1.40/ft²
	Sponge Blasting DCON-58-OG	**Accepted** Although the technology is relatively new, it is currently being used by at least two sites including a nuclear power plant. Extensive data on decontamination factors are not available. With the aggressive sponges, which are impregnated with abrasives this technology, may be effective for the listed contaminants and substrates. Wastes consist of about 0.01 ft³ of blasting media and removed contaminants per ft² of area decontaminated plus any liquid cleaning agents that may have been added.	Development - To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so that the water can be recycled and reused in the sponge blasting operation.	Prior removal and disassembly of contaminated equipment and a glove box or room that is easily decontaminated in which the decontamination will be accomplished plus a wastewater treatment / recycle system will be needed to use this technology.Development costs: About $1.2M Capital cost: Sponge blasting system: About $20K (with blasting media wash unit for a robotic system) Glove box: <$50K Work room: About $250K Operating cost: About $2/ft²

Technology Lo

Decontamin

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Building →	Concrete U Tc Actinides Chromate Oil PCB →	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified. →	Decontamination →	Cher
	Process Support Building				
	Pumping Stations				
	Laboratory Facilities				
	Special Development Facilities				
	Administrative Facilities				
	Cooling Towers				

EM Problem

- Decommissioning (D&D) → K-25 Site Problem
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram
tamination

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Chemical Surface Cleaning	Caustic Treatments DCON-13-OG	**Accepted** Decontamination of surface smearable contamination using caustic chemicals (principally soap and water) has been used at K-25 for many years. Since many of the listed contaminants are expected to be fixed or to have penetrated, at least partially, into the concrete, caustic scrubbing is expected to only partially decontaminate the contaminated concrete. Wastes would consist of used caustic solution containing the removed contaminants.	None	A waste treatment plant is needed to treat the wastewater resulting from the decontamination operation. Capital cost: <$10K Operating cost: >$1/ft² (<$1/ft² with a riding scrubber)
	Biological DCON-17-OG	**Evolving Technology** Pre-conceptual - The knowledge base exists for biological treatments of various contaminants; however, there is not a data base for application of the technology for surface decontamination. This technology is quite likely to be successful for oil and PCBs. It could be successful for U, Tc, actinides, and chromates, but these contaminants would remain in the bacterial sludge. The waste generated would be the contaminated layer of microbes removed from the treated surface.	Science - Literature study and bench-scale tests of microbes on U, Tc, actinides, and chromates. Development - Develop methods for applying a layer of microbes, supplying needed nutrients, and removing the microbe layer from the decontaminated item.	Facilities for cultivating the bacteria and disposing of the bacterial sludge would be needed. Development cost: $300K-$600K Capital cost: About $200,000 Operating cost: $0.10-$3.00+/ft²
	Electromigration DCON-20-OG	**Evolving Technology** Pre-conceptual - Initial data indicate 90+% removal of U & Tc from concrete. Applicable, in principle, to actinides & chromate. Removal of oil & PCBs possible, in principle, but not demonstrated. Wastes would be electrolytes containing removed contaminants and scrap cell components.	Development - Additional small-scale "proof of principle" tests are needed followed by larger scale field demonstration. A treatment system that would permit recycle of the electrolyte is needed.	Normal implementation needs. Development costs: $1.7M Capital cost: About $200K Operating cost: About $5/ft²
	Fluoboric Acid Treatment DCON-11-OG	**Demonstration** The technology was specifically designed for D&D (Chernobyl application) and is likely to be highly effective. It removes the outer layer in a controlled and effective manner. The acid can be electrolytically regenerated and recycled with radioactive waste plated out at the cathode and solidified in cement. Final quantity of cement-solidified waste is 20-50 grams/m² of decontamination surface. Other waste treatment options are possible.	Development - Although the method has seen application at Chernobyl with good results, development work is needed to test applicability at US GDPs.	Normal implementation needs. Development cost: $400-1000K (Rough estimate) Capital cost $800K (1990 estimate for equipment only for 5T/day capacity of metal) $4-10M (rough estimate including engineering and facilities) Operating cost: ~$300/metric tons (assume same as for BNFL process)

Technology Logic

Decontaminatio

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternative
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Building	Porous Nickel U Tc Actinides Porous Aluminum U Tc Actinides	Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Chemical Surface Cleaning Methods Metal Refining

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

ogic Diagram
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Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Chemical Surface Cleaning Methods	Gas Phase Decon DCON-16-OG	**Pre-demonstration** Lab-scale studies have demonstrated that ClF3 is capable of effectively removing U deposits at room temperature. Gas phase decontamination is expected to be largely or completely effective in removing U compounds found in gaseous diffusion equipment. It should be partially effective in removing Tc. Actinides and thorium daughter products from the decay of U compounds will not be removed. The levels of the latter contaminants on much, or most, of the substrates will still meet surface release criteria. Wastes will be spent NaF trapping material and spent caustic scrubber solution or fluoride trapping media.	Science - Optimum process conditions for decontamination should be established. Effectiveness should be demonstrated on small samples. Development - Full-scale demonstration of the decontamination of process equipment is needed. Development of mechanical methods and chemical methods to remove reaction by-products so that ClF3 can be recycled is needed.	A permitted vent will be needed to implement this technology. Air with trace amounts of UF_6, chlorides, and fluorides will be vented. Development cost: About $5M Capital cost: >$3M/unit Operating cost: About $15,000 ($0.52/lb) if a 00 converter is treated in situ.
	Inorganic Acid Treatments DCON-12-OG	**Accepted** Decontamination with nitric acid has been used for cleaning converters and other large items at K-25 for many years. Sulfuric acid is used less often, notably to dissolve nickel plating prior to removing contaminants at the nickel-steel interface. The inorganic acids are concentrated, with concurrent corrosion. DFs are in the 100 range. Wastes consist of large quantities of corrosive wastes containing the removed contaminants and require treatment and disposal as mixed waste.	Development- Necessary to adapt modifications to the system (scrubbers, filters, treatment for nitrates and heavy metals) to recycle reagents to meet regulatory requirements. Science/Development- Possible development of the HNO3/HF decontamination method, with or without ultrasonic agitation.	Normal implementation needs. Development cost: $400-1000K (Rough estimate) Capital cost: <$4-10 million (Rough estimate) Although existing facilities may be adaptable to the acid cleaning process, a treatment facility for corrosive nitrate wastes will be required. Operating cost: Similar to the other organic and inorganic treatment systems.
Metal Refining	Smelt Purification DCON-31-OG	**Demonstration** Performed by many investigators on a lab scale and by some on a large scale. U removed to 0.01 - 4 ppm for Ni, 3 - 100 ppm for Al. Tc not removed. Wastes are slags, scrubber solutions, chemical trap materials, and HEPA filters containing removed contaminants. Fifty lb of slag generated/ton metal.	Science- Demonstrate fluxing agent for removing Tc. Development- Demonstrate improved purification for Al.	Standard induction arc furnace with off-gas treatment system. Development cost: $3 - 5M Operating plus capital cost: ~$1/lb based on 8 ton electric induction furnace. A *de minimus* standard is needed to allow sale of the purified metal.
	Electrorefining DCON-32-OG	**Predemonstration** Not demonstrated on a large scale for the decon. of radioactive materials. Tc plates out on cathode with Ni. Technology is likely to be effective. Waste electrolyte solutions will be a mixed waste.	Development- Demonstrate techniques to (1) prevent Tc from plating out with Ni and Al, (2) reduce U contamination in refined Al; and (3) recycle electrolytic solutions.	Smelter to cast anodes. Development cost: $3 - 4M Operating cost > $2 - 6/lb Capital cost for a 10 million-pound/y plant: $200 million A *de minimus* standard is needed to allow sale of the purified metal

Technology Lo

Decontamin

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Building	<u>Porous Nickel</u> U Tc Actinides <u>Porous Aluminum</u> U Tc Actinides	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Meta (cont. Bulk Met

EM Problem

- Decommissioning (D&D) → Enrichment Process Building
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram
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Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Metal Refining (cont.)	Nickel Carbonyl Mond Process DCON-33-OG	**Demonstration** Level of U contamination in Ni produced by process demonstrated to be I pCi/g. Process will be successful for Al. Tc is not removed, but decon level is not documented. Uses very hazardous materials. Waste is contamination & catalyst left behind.	Development- Demonstrate level of Ni purification from Tc & other radioactive contaminants.	Normal implementation needs. Development cost: $750 - 3000K Capital cost: $600M* Operating cost: $6/lb* *Based on a 5000 ton/y plant A *de minimus* standard is needed to allow sale of the purified metal
	Leach/Electrowinning DCON-34-OG	**Predemonstration** Although this process is a well establ'shed commercial process for producing nickel from ore, it has not been demonstrated for purifying nickel metal contaminated with radioactive elements on a large scale. SEG has demonstrated the method on a small scale to purify Ni to < 1 bq/g of Tc. The method is similar to electrorefining except the metal is first dissolved into solution rather than formed into anodes. The Tc must be removed from the electrolytic solutions by ion exchange or some other method. Recycle of the electrolytic solutions will result in a mixed solid waste bearing Ni, U, Tc, and other compounds amounting to 2% of the Ni processed.	Development - Demonstrate techniques to recycle the electrolytic solutions.	Implementation needs: Development Costs: about $500K Operating plus capital cost: >$4-6/lb Capital cost for a 10 million pound/y plant: $200 million A *de minimus* standard is needed to allow sale of the purified metal
Bulk Decontamination Methods	Catalytic Extraction Process DCON-6-OG	Predemonstration- Has not been used to smelt scrap bearing radioactivity. Likely to reduce Ni to 0.01 - 4 ppm U and Al to 3 - 100 ppm U or less. Tc is not removed. Wastes would be 50 lb. of slag containing contamination per ton of scrap metal processed plus contaminated scrubber solution or chemical trapping materials.	Science- Method for removing - Tc. Development - Tc removal and improved U removal.	"Off-the-shelf" induction or arc furnace with off-gas treatment. Development cost: $3 - 5M Operating plus capital cost: ~$1/lb A *de minimus* standard is needed to allow sale of the purified metal

Technology Lo

Decontamin

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Building Process Support Building Special Development Facilities Administrative Facilities	Transite (Asbestos) U Oil Tc PCBs Actinides Chromate	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmenta' aws, signed and pending ag:eements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Bulk Meth
		Asbestos Pipe Insulation U Tc PCBs			
	Cooling Towers	Munter's Fill As Chromates Ba Dioxins Asbestos			

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

ogic Diagram
mination

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Bulk .' ec: contamination Methods	Solvent Extraction DCON-1-OG	**Demonstration** Technology has been used, but not for these contaminants and substrates, efficacy needs demonstration; waste would be solvent contaminated with removed contaminants.	Development - Literature search to determine solvent to be used plus small-scale demo of efficacy. Development of waste treatment system for treatment or recycle of spent solvent.	Extensive chemical processing system for solvent treatment with a waste treatment system for treatment or recycle of spent solvent Development Cost: Efficacy demo: $200-$1000 K/application Waste treatment: $1-4M Capital Costs - Solvent treatment: $20-$100M Waste treatment: $20-$100M Operating Cost: $5-50/lb
	Dry Heat DCON-4-OG	**Predemonstration** Although roasting is an accepted technique for removing volatile contaminates from solid surfaces, the effective use of dry heat for these problems is uncertain and untried. Technique is likely to be effective for removing oils, but not for destroying PCB's Tc might be removed. Waste would be original materials containing original contaminants except for oils and, perhaps, TC and caustic scrubber solution containing Tc.	Development: Bench-scale tests are needed to establish which contaminants can be removed from these materials and what secondary waste treatment would be needed. The availability of engineered equipment is judged adequate if the lab studies verify effective contamination removal by heat.	Normal implementation needs. Development cost: $200-$1000 K/material Capital cost: $1-25M Operating cost: $1-$10/lb
	Chemical Leaching DCON-5-OG	**Predemonstration** Although chemical leaching is an accepted technique for some applications, bench scale tests are needed to determine which chemical would be effective. Waste would be original materials contaminated with chemical leachates plus chemical leachates containing removed contaminants or sludges, filter cakes, and ion exchange resin from recycle system containing removed contaminants.	Development: Bench scale tests are needed to determine which chemicals would be effective and what secondary waste treatment would be necessary to recycle chemicals.	Extensive chemical processing system for chemical leaching with a waste treatment system for treatment or recycle of spent chemical leaching solution. Development Cost Efficacy demo: $200 - $1000K/application Waste treatment: $' - 4M Capital Costs Chemical leaching: $30 - $150M Waste treatment: $30 - $150M Operating Cost: $5 - $50/lb
	Catalytic Extraction Process DCON-6-OG	**Predemonstration** Has not been used for these materials or for scrap having radioactivity. A method capable of adequately removing Tc has not been demonstrated. PCBs, oil, and dioxins should be destroyed. With the proper slag, U and other contaminants should be removed. Asbestos might be converted to glass. Waste would be slag containing metallic contaminants plus contaminated scrubber solution or chemical trap materials.	Science - Technique for Tc removal. Development - Demonstrate effectiveness for materials of interest	"Off-the-shelf" induction or arc furnace with off-gas treatment system. Development cost: $3 - 5M Capital cost: 1/2 of an incinerator of equal capacity ~$16M Operating cost: 1/3 of an incinerator $2 - 3/lb
	Vacuum DCON-7-OG	**Accepted** Proprietary vacuum process to remove Cr+6 from transite. Technique should also work on asbestos pipe insulation and Munter's fill. Technique is not expected to work for any contaminant other than Cr+6. Waste would be caustic scrubber sol'n containing removed Cr.	None	Large blower systems are needed to draw a vacuum on the building, sprayer systems are needed to spray acid on the material. Capital and operating cost are considered proprietary. Rough guesses follow. Capital cost: $1 -10M Operating cost: $2 - 8/ft²

Technology Lo

Decontamin am

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Building Process Support Building Special Development Facilities Administrative Facilities	Transite (Asbestos) U Oil Tc PCBs Actinides Chromate Asbestos Pipe Insulation U Tc PCBs	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific char cteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Buil Met (co Sur
	Cooling Towers	Munter's Fill As Chromates Ba Dioxins Asbestos			

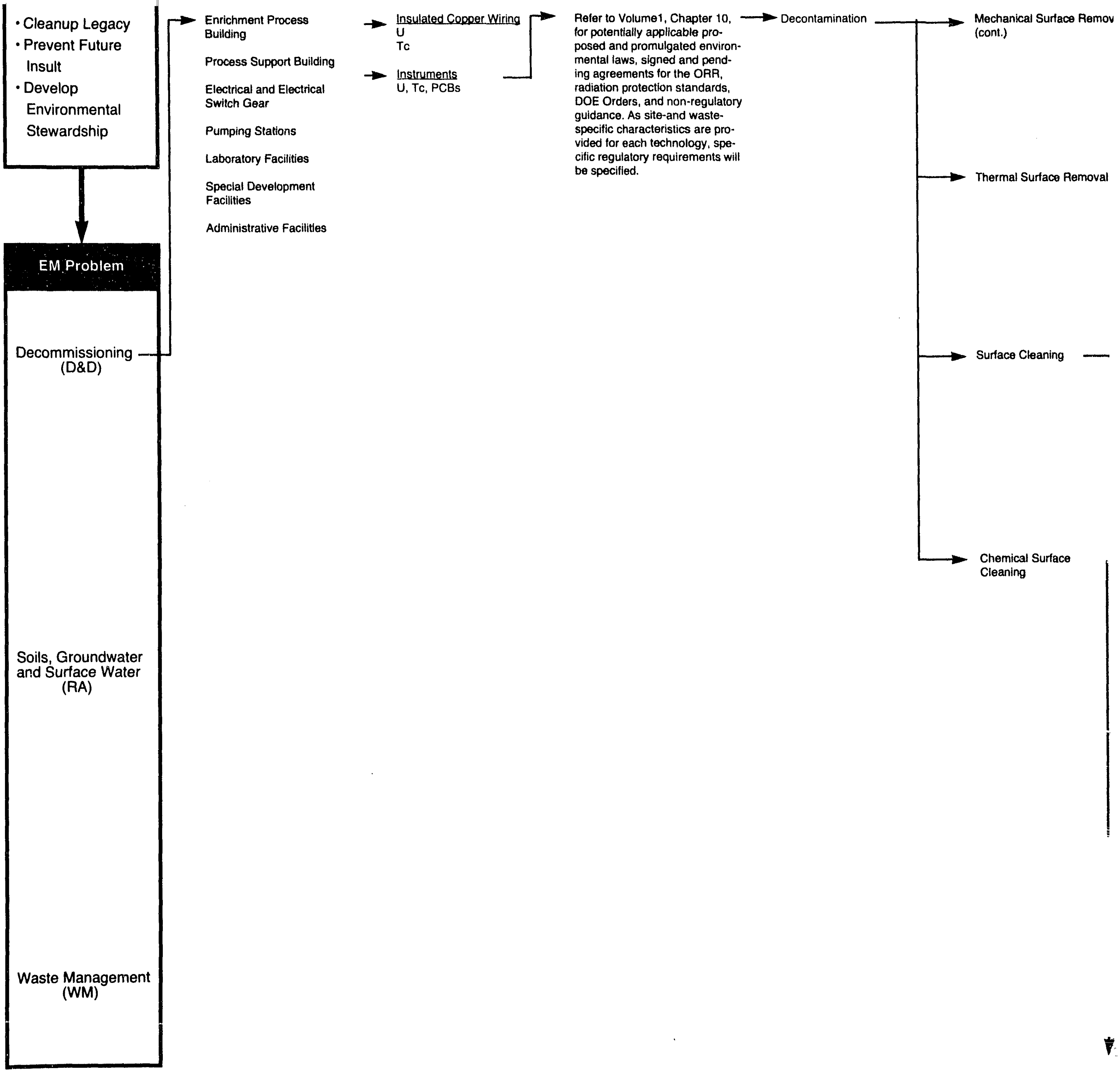
EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
Enrichment Process Building Process Support Building Electrical and Electrical Switch Gear Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities	Insulated Copper Wiring U Tc Instruments U, Tc, PCBs	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Mech Rem

Logic Diagram
amination

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Bulk Decontamination Methods (cont.)	Incineration DCON-2-OG	**Accepted** Incineration is being used at K-25. A new incinerator would be needed because the existing incinerator cannot accept waste with more than 5 ppm total uranium and enrichments higher than one percent ^{235}U. Efficacy - The K-1435 incinerator gives 99.99 to 99.999% destruction and removal efficiency when burning toxic organics. Waste generated - This will depend on the design of the incinerator and the ash content of the waste being burned. During a test, the K1435 incinerator generated 1.1 gallons of wastewater and 27 pounds of ash per 100 pounds of waste fed.	None	A new incinerator would be needed to burn wastes contaminated with enriched uranium. The present incinerator requires the services of about 30 maintenance workers (maintenance mechanics, electricians, pipe fitters, welders, and instrument mechanics), their supervisors, 34 chemical operators, their supervisors, and 7 engineers. About 8-10 years is required for writing an environmental impact statement, holding public hearings, and obtaining the necessary permits - TSCA permit, RCRA permit, NESHAP permit, and Clean Air Act permits. Cost: capital cost $26 million (1987 dollars) Operation cost $10/lb (1992 dollars)
Surface Cleaning Methods	Compressed Air Cryogenic CO_2 Blasting DCON-51-OG	**Demonstration** This technology is commercially available. It has been used at nuclear reactor sites to decontaminate hand tools and some equipment. The efficacy of this technology for removing the listed contaminants from the listed substrates has not been demonstrated. The technology could possibly be used on transite and Munter's fill, but probably not on asbestos pipe insulation. Wastes would be HEPA filters filled with the removed contaminants and, possibly, some removed substrate.	Development - Demonstration of the efficacy of this technology for the listed contaminants and substrates.	Prior removal and disassembly of contaminated equipment and a glove box or room that is easily decontaminated in which the decontamination will be accomplished plus design and construction of a vacuum waste-handling system with HEPA filters to handle the vaporized CO_2 containing the removed contaminants are needed to use this technology. A vacuum collection system with well designed nozzles might permit in situ decontamination of assembled equipment. Development costs: $750-$3000K Capital cost: CO_2 system: About $200K Glove box: <$50K Work room: About $250K Operating cost: $2-$20/ft^2
Mechanical Surface Removal	Supercritical CO_2 DCON-41-OG	**Predemonstration** Being developed by FLOW International Corp.; effectiveness remains to be demonstrated; waste will be prefilters and HEPA filters filled with contaminants	Development - Evaluate the effect of operating parameters on the removal of various contaminants from different substrates Improvement - Containment and vacuum recovery system	Normal implementation needs. Development costs: $250K - $1000K Capital cost: $150K/machine Operating cost: ~ $ 2/ft^2



• Cleanup Legacy
• Prevent Future Insult
• Develop Environmental Stewardship
EM Problem
Decommissioning (D&D)
Soils, Groundwater and Surface Water (RA)
Waste Management (WM)
Enrichment Process Building
Process Support Building
Electrical and Electrical Switch Gear
Pumping Stations
Laboratory Facilities
Special Development Facilities
Administrative Facilities
Insulated Copper Wiring
U
Tc
Instruments
U, Tc, PCBs
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Decontamination
Mechanical Surface Remov
(cont.)
Thermal Surface Removal
Surface Cleaning
Chemical Surface Cleaning

ogic Diagram
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Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Mechanical Surface Removal (cont.)	Plastic Pellet Blasting DCON-42-OG	**Accepted** Plastic pellet blasting is a widely used alternate to sand blasting for applications in which it is desired to impart minimal damage to the substrate. Technology should remove smearable, but not fixed contamination. Waste would be spent plastic pellets plus removed contamination.	Development - Develop and demonstrate a system for processing waste. Improvement - Minimize blast media erosion to minimize waste; automation/robotics; improved containment of waste and removed contaminants.	A system for processing waste to an acceptable form is needed. Development cost: $5.5M+ Capital cost: About $50K Operating cost: $0.20-$2.15/ft^2 for flat surfaces
Thermal Surface Removal	Laser Heating DCON-73-OG	**Demonstration** Currently being evaluated by Air Force as a method for removing organic coatings from metal; current systems are capable of removing 2-mil thick coatings at the rate of 100 ft^2/hr.; waste will be pre-filters and HEPA filters filled with contaminants.	Development - Demonstration of decon. capability of existing lasers.	Normal implementation needs plus automation Development costs: $2M + Capital cost: $1-10M/machine Operating cost: ~ $ 2/ft^2
Surface Cleaning	Strippable Coatings DCON-63-OG	**Accepted** Technology has been used for decontamination applications involving hazardous and radioactive contaminants. Decontamination factors of one to several hundred can be expected with two applications. Waste is a solid polymer (volume = 1 mm x surface area decontaminated) containing the removed contaminants.	Improvement: Develop coatings with lower material costs and greater ease of application and effectiveness	Normal implementation needs. Capital costs: Negligible Operating cost: $ 1 to 1.40/ft^2
Chemical Surface Cleaning	Biological DCON-17-OG	**Evolving Technology** pre conceptual Organisms that destroy PCB's have been identified. Method is unlikely to decon. U&Tc. Waste would be a sludge containing remains of bacteria + PCB's and inorganic contaminants. Methane is a likely gaseous product.	Science - Find culture techniques that provide successful decon on a lab scale. Development - Develop techniques that successfully decon on large scale. Develop equipment cost and decon rate and cost information.	A bioreactor for continuously growing new bacteria on a large scale would be needed. Insufficient information exists to project even order of magnitude capital or operating costs. Development costs: $3 - 10M
	Laser Activated Chemistry DCON-18-OG	**Evolving Technology** Acceleration of reaction rates for selected reactions is proven. Small scale decon has been demonstrated. Waste would be prefilters and HEPA filters filled with removed contaminants.	Development - Demonstration of vacuum systems capable of collecting removed contaminants.	Normal implementation needs. Development costs: $2M + Capital cost: $1-10M/machine Operating cost: Unknown

Technology Lo

Decontamin

EM Goals
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship

EM Problem
Decommissioning (D&D)
Soils, Groundwater and Surface Water (RA)
Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
Enrichment Process Building Process Support Building Electrical and Electrical Switch Gear Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities	Insulated Copper Wiring U Tc Instruments U, Tc, PCBs	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Che Cle (co
Enrichment Process Building Process Support Building Laboratory Facilities Special Development Facilities Administrative Facilities	Freon	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Bu Ma

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Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Chemical Surface Cleaning (cont.)	Solvent Washing DCON-61&62-OG	**Conceptual** Solvent cleaning of small items has been used at K-25 and the cleaning of larger areas has been demonstrated at Richland. The use of solvent cleaning has been stopped at both sites to avoid exposing workers and the environment to the hazardous solvents. Other solvents may be available, but their effectiveness would have to be demonstrated. Efficacy - This method is only effective on smearable contamination. Waste would be spent solvent containing contaminants.	Development-Solvents that are less harmful to health and the environment need to be identified and demonstrated.	Solvent off-gas collection and treatment system would be needed. Development cost - $1-4.5M Capital Cost: $400K (4K lb. unit) Operating Cost: $0.10 - $1.00/lb.
	Inorganic Acid Treatments DCON-12-OG	**Accepted** Decontamination with nitric acid has been used for cleaning converters and other large items at K-25 for many years. Sulfuric acid is used less often, notably to dissolve nickel plating prior to removing contaminants at the nickel-steel interface. The inorganic acids are concentrated, with concurrent corrosion. DFs are in the 100 range. Wastes consist of large quantities of corrosive wastes containing the removed contaminants and require treatment and disposal as mixed waste.	Development- Necessary to adapt modifications to the system (scrubbers, filters, treatment for nitrates and heavy metals) to recycle reagents to meet regulatory requirements. Science/Development-Possible development of the HNO3/HF decontamination method, with or without ultrasonic agitation.	Normal implementation needs. Development cost: $400-1000K (Rough estimate) Capital cost: <$4-10 million (Rough estimate) Although existing facilities may be adaptable to the acid cleaning process, a treatment facility for corrosive nitrate wastes will be required. Operating cost: Similar to the other organic and inorganic treatment systems.
	Caustic Treatments DCON-13-OG	**Accepted** Decontamination of surface smearable contamination using caustic chemicals (principally soap and water) has been used at K-25 for many years. Since many of the listed contaminants are expected to be fixed, caustic scrubbing is expected to only partially decontaminate the contaminated surfaces. Wastes would consist of used caustic solution containing the removed contaminants.	None	A waste treatment plant is needed to treat the wastewater resulting from the decontamination operation. Capital cost: <$10K Operating cost: >$1/ft^2
Bulk Decontamination Methods	Incineration DCON-2-OG	**Accepted** The TSCA incinerator gives 99.99 to 99.9999% destruction and removal efficiency for freon Waste; 1.1 gal of waste scrubber solution per 100 lb. of waste fed.	None	Waste treatment facilities for caustic scrubber solution. Development Cost: None Capital cost (new TSCA) Incinerator: $32M Operating Cost: $6-10/lb.

Technology Logic
Decontamination

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternatives
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Building Process Support Building Laboratory Facilities Special Development Facilities Administrative Facilities	<u>Freon</u>	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Bulk Decontamination Methods
EM Problem Decommissioning (D&D)	Enrichment Process Building Process Support Building Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Cooling Towers	<u>Tile</u> <u>Wood</u> As Chromates Ba Dioxins <u>Gasket Material</u> PCBs U <u>Composite Roofing</u> U, Tc	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Mechanical Substrate Surface Removal
Soils, Groundwater and Surface Water (RA)					
Waste Management (WM)					

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Bulk Decontamination Methods	Catalytic Extraction Process DCON-6-OG	**Pre-demonstration** Has not been used for freon. Should be effective in destroying freon. Waste; about the same amount of scrubber solution for freon.	Development- Bench scale followed by large-scale demo that process will destroy freon.	"Off-the-shelf" induction or arc furnace with off-gas treatment system. Development cost: $3-5M Capital cost: ~$16M Operating Cost: $2-3/lb.
	Other (distillation, filtration, etc.)	Other technologies, which are commonly used in a large variety at applications other than for decontamination purposes could be used to decon freon.		
Mechanical Substrate Surface Removal	Ultrahigh Pressure Water DCON-35-OG	**Accepted** This technology has been used by industry. Waste - Unless a recycle system is developed, 3 - 5 gallon wastewater per sq. ft. The wastewater would contain the removed contaminants and about 0.01 cubic feet of substrate per square foot treated.	Development - To minimize waste generation, a system is needed to treat the water so it can be recycled.	Normal implementation needs. Development cost - $1.3M Capital cost - ~$500K Operating cost - ~$1/ft^2
	Ice Blasting DCON-40-OG	**Demonstration** Efficacy of commercial systems for this application needs demonstration. Waste - wastewater containing removed contaminants.	Development - water recycle system; automation/robotics	Normal implementation needs. Capital cost: $100K - $1M Operating cost: <$1/sq. ft.
	Supercritical CO_2 DCON-41-OG	**Pre-demonstration** This technology is being developed by a private company. Likely to be effective with nearly infinite decontamination factors. Waste would be removed substrate and contaminants contained in a cyclone and a HEPA filter.	Development - Investigate the effect of operating parameters on removal rates and removal and collection efficiencies for contaminants. Demonstrate efficacy for contaminants of interest.	Normal implementation needs plus oxygen depletion precautions. Development cost: $1M - $4M Capital cost: $500K - $1000K Operating cost: $1+/sq. ft.
	Plastic Pellet Blasting DCON-42-OG	**Accepted** Plastic pellet blasting is a widely used alternate to sand blasting for application in which it is desired to impart minimal damage to the substrate. Technology should remove smearable, but not fixed contamination from tile and wood. Fixed contamination and some substrate should be removed from composite roofing. Waste would be spent plastic pellets plus removed contamination. Waste would contain some wood and considerable composite roofing when decontaminating these substrates.	Development - Develop and demonstrate system for processing waste. Improvement - Minimize blast media erosion to minimize waste; automation/robotics, especially for walls, etc.; improved containment of waste, removed contaminants, and any removed substrate material.	A system for processing waste to an acceptable form is needed. Development cost: $5.5M+ Capital cost: About $50K Operating cost: $0.20-$2.15/ft^2

Technology Lo

Decontamin

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Building Process Support Building Laboratory Facilities Special Development Facilities Administrative Facilities Cooling Towers	<u>Tile</u> <u>Wood</u> As Chromates Ba Dioxins <u>Gasket Material</u> PCBs U <u>Composite Roofing</u> U, Tc	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Med Surf (con The Mei Surf

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram
ntamination

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Mechanical Substrate Surface Removal (cont.)	Shot Blasting DCON-36-OG	**Accepted** - Commercial iron shot blasters are in use at the K-25 Site. Behavior on tile would be similar to that on concrete. Not suitable for use on gasket material. Should be generally effective but leave some hot spots. Waste would be removed substrate and contaminants contained in filters.	Improvement - Automation	Normal implementation needs Development cost: 1-4 M Capital cost: About $50K Operating Cost: About $0.03/ft^2
	Grit Blasting DCON-38-OG	**Accepted** - Has been used successfully for many application in the nuclear industry. Technology is generally effective, but not suitable for gasket materials. Waste would be spent grit, abraded substrate, and contaminants in filters and HEPA filters.	Improvements - Automation; better vacuum system.	A vacuum collection system with pre-filters and HEPA filters would be needed to use this technology. Development cost: $4-10M Capital cost: About $500K Operating cost: <$2/ft^2
	Centrifugal Cryogenic CO_2 Blasting DCON-39-OG	**Pre-demonstration** Centrifuge pellet acceleration has been demonstrated in the DOE fusion energy program. Technology is likely successful with essentially infinite decontamination factors. Waste would be filters and HEPA filters filled with removed contaminants and a small amount of removed substrate.	Development - Demonstration of a practical system with high velocity pellets delivered at a sufficient rate and adequate collection of removed contaminants.	Normal implementation needs (vacuum collection system with adequate filters) plus oxygen-depletion precautions. Development cost: About $3.4M Capital cost: About $200K Operating cost: $0.25-$0.75/ft^2
Thermal Surface Removal Methods	Plasma Torch DCON-72-OG	**Evolving Technology** *Conceptual* - Plasma torches exist commercially to weld and cut materials that have very high melting temperatures or require an inert atmosphere. Its efficacy in removing various organic contaminants or to spall off or vaporize layers of contaminated substrates have not been investigated. Wastes would consist of materials used to trap reaction products from the decomposition or vaporization of organics, removed substrates, and removed inorganic contaminants.	Science - Laboratory tests are needed to evaluate the efficacy of vaporizing or decomposing organics, determine the decomposition reaction by-products, and suitable trapping materials. Computer modeling of plasma surface interactions, heat transfer in the substrates, and thermally induced stresses are needed. Development - Plasma torches having geometries and conditions suitable for decontamination needs to be developed along with suitable gas collection and treatment systems.	Gas collection and treatment system is needed for this technology. Development cost: About $3M Capital cost: About $200K Operating cost: $0.01-$1.00/ft^2
Surface Cleaning	High-Pressure Water DCON-52-OG	**Accepted** High pressure water blasting has been used very successfully to decontaminate various large and complex surfaces at nuclear power plants. Technique is expected to be effective with a DF of about 50 for loosely adhering contamination. DF's will be higher if chemical cleaning agents are also used. Technique is expected to be ineffective for fixed contamination on tile Waste - 4 to > 100 gpm of contaminated waste water.	Development - To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so the water can be reused. Improvement - Remote operation will require adapting the high pressure water and vacuum collection systems to robotic system control.	Normal implementation needs. Development costs - water treatment system: about $1.2M Remote operation:$3M - $4M Capital cost - $50K - $75K (about $250K with remote operation) Operating cost - $0.03 - $1.00/sq. ft.

Technology Logi

Decontaminatio

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternat
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Building Process Support Building Laboratory Facilities Special Development Facilities Administrative Facilities Cooling Towers	Tile Wood As Chromates Ba Dioxins Gasket Material PCBs U Composite Roofing U, Tc	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Surface Cleani (cont.)

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram
tamination

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Surface Cleaning (cont.)	Superheated Water DCON-53 -OG	**Accepted** Technology is available and has been used by industry. Technology should be effective except for fixed insoluble contamination or contamination that has soaked into the substrate. Waste - 0.4 to 2.0 gpm wastewater containing removed contaminants.	Development - To minimize waste generation, a water treatment system is needed to decontaminate the water for recycling. Improvement - Remote operation will require adapting the superheated water and vacuum collection systems to robotic system control.	Normal implementation needs. Development cost - Water treatment system: about $1.2M Remote operation: $3M - $4M Capital cost - About $175K (about $250K with remote operation) Operating cost - $0.03 - $1.00/sq. ft.
	Steam DCON-55-OG	**Accepted** The technique has proven useful, especially on comp;lex shapes and large surfaces. Technology should be effective except for fixed insoluble contamination or contamination that has soaked into the substrate. Waste - 0.4 to 2.0 gpm wastewater containing the removed contaminants.	Development - To minimize waste generation, a water treatment system is needed to decontaminate the water for recycling. Improvement - Remote operation will require adapting the steam and vacuum collection systems to robotic system control.	Normal implementation needs. Development cost - Water treatment system: about $1.2M Remote operation: $3M - $4M Capital cost - $50K - $75K (about $250K with remote operation) Operating cost - $0.03 - $1.00/sq. ft.
	Solvent Washing DCON-62&63-OG	**Conceptual** Solvent cleaning of small items has been used at K-25 and the cleaning of larger areas has been demonstrated at Richland. The use of solvent cleaning has been stopped at both sites to avoid exposing workers and the environment to the hazardous solvents. Other solvents may be available, but their effectiveness would have to be demonstrated. Efficacy - This method is only effective on smearable contamination. Waste would be spent solvent containing contaminants.	Development-Solvents that are less harmful to health and the environment need to be identified and demonstrated.	Solvent off-gas collection and treatment system would be needed. Development cost - $1-4.5M Capital Cost: $400K (4K lb. unit) Operating Cost: $0.10 - $1.00/lb.
	Strippable Coatings DCON-63-OG	**Accepted** This technology has been used for decontamination purposes in applications involving hazardous and/or radioactive contaminants. Efficacy - Decontamination factors of 100 to several hundred. Waste - 1 gallon of contaminated solid polymer /50 sq. ft.	Improvements - Potential areas of improvement are greater ease of application, reduction of material costs, and increased effectiveness.	Development costs - $500K Capital cost -<10K Operating cost -$2-$2.4/sq. ft.

Technology Lo

Decontamin

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

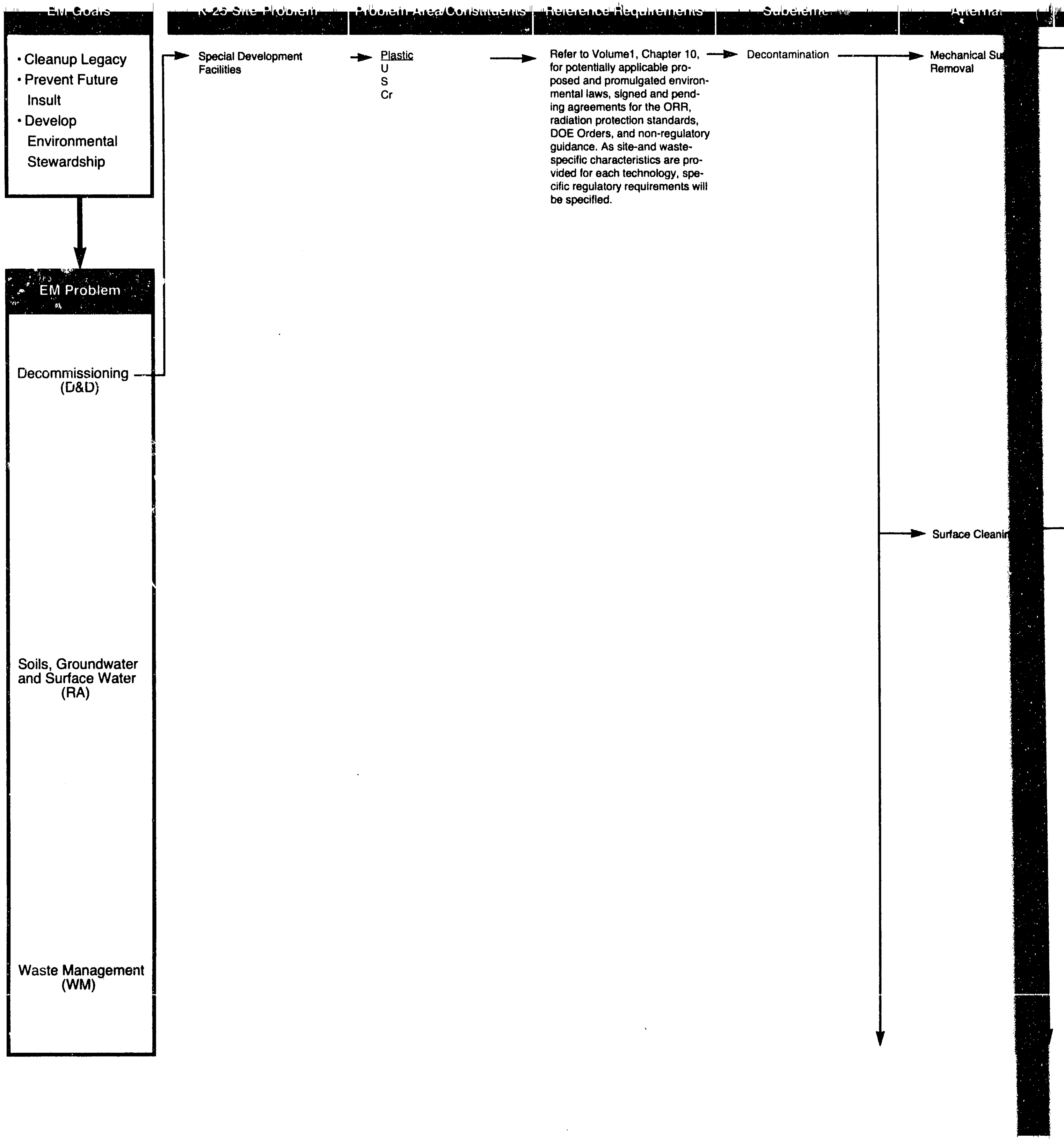
EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
Enrichment Process Building Process Support Building Laboratory Facilities Special Development Facilities Administrative Facilities Cooling Towers	Tile Wood As Chromates Ba Dioxins Gasket Material PCBs U Composite Roofing U, Tc	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Bulk Meth

Bulk Decontamination Methods

Solvent Extraction DCON-1-OG	**Demonstration** Technology has been used but not for these contaminants and substrates. Efficacy - needs demonstration. Waste - solvent contaminated with removed contaminants.	Development - Literature search to determine solvent to be used plus small scale demo of efficacy.	Extensive chemical processing system for solvent treatment with a waste treatment system for the treatment or recycle of spent solvent. Development cost - efficacy demo - \$200K to \$1000K /application waste treatment - \$1M to 4M Capital costs - solvent treatment -\$20M-100M waste treatment - \$20M-100M Operating costs - \$5 - \$50/lb
Incineration DCON-2-OG	**Accepted** Incineration is being used at K-25. A new incinerator would be needed because the existing incinerator cannot accept waste with more than 5 ppm total uranium and enrichments higher than one percent ^{235}U. Efficacy - The K-1435 incinerator gives 99.99 to 99.999% destruction and removal efficiency when burning toxic organics. Waste generated - This will depend on the design of the incinerator and the ash content of the waste being burned. During a test, the K1435 incinerator generated 1.1 gallons of wastewater and 27 pounds of ash per 100 pounds of waste fed.	None	A new incinerator would be needed to burn wastes contaminated with enriched uranium. The present incinerator requires the services of about 30 maintenance workers (maintenance mechanics, electricians, pipe fitters, welders, and instrument mechanics), their supervisors, 34 chemical operators, their supervisors, and 7 engineers. About 8-10 years is required for writing an environmental impact statement, holding public hearings, and obtaining the necessary permits - TSCA permit, RCRA permit, NESHAP permit, and Clean Air Act permits. Cost: capital cost \$26 million (1987 dollars) Operation cost \$10/lb (1992 dollars)
Biological DCON-3-OG	**Pre-conceptual** Efficacy - unknown Waste generated - unknown	This technology would have to be developed and scaled-up. The efficiency of this method would have to be demonstrated to the satisfaction of the State and Federal agencies that control the disposal of hazardous organics and PCBs. There is a possibility that the organisms could produce other toxic chemicals.	Development costs - >\$4M capital cost - unknown operating cost - unknown


EM Goals
• Cleanup Legacy
• Prevent Future Insult
• Develop Environmental Stewardship
EM Problem
Decommissioning (D&D)
Soils, Groundwater and Surface Water (RA)
Waste Management (WM)
Special Development Facilities
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Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Decontamination
Removal

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tamination

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Mechanical Surface Removal	Ultrahigh-Pressure Water DCON-35-OG	**Accepted** This technology has been used by industry. Waste - Unless a recycle system is developed, 3 - 5 gallon wastewater per sq. ft. The wastewater would contain the removed contaminants and about 0.01 cubic feet of substrate per square foot treated.	Development - To minimize waste generation, a system is needed to treat the water so it can be recycled.	Normal implementation needs. Development cost - $1.3M Capital cost - ~$500K Operating cost - ~ $1/sq. ft.
	Ice Blasting DCON-40-OG	**Accepted by Industry** Efficacy of commercial systems for this application needs demonstration at K-25. Waste about 14 to 18 gallon per hour wastewater containing removed contaminants.	Development - automation/robotics	Normal implementation needs. Development cost: $1.2M Capital cost: $100K - $1M Operating cost: <$1/sq. ft.
	Supercritical CO_2 Blasting DCON-41-OG	**Pre-demonstration** This technology is being developed by a private company. Likely to be effective with nearly infinite decontamination factors. Waste would be removed substrate and contaminants contained in a cyclone and a HEPA filter.	Development - Investigate the effect of operating parameters on removal rates and removal and collection efficiencies for contaminants. Demonstrate efficacy for contaminant of interest.	Normal implementation needs plus oxygen depletion precautions. Capital cost: $500K - $1000K Operating cost: $1+/sq. ft.
Surface Cleaning	High-Pressure Water DCON-52-OG	**Accepted** High pressure water blasting has been used very successfully to decontaminate various large and complex surfaces at nuclear power plants. Technique is expected to be effective with a DF of about 50 for loosely adhering contamination. DF's will be higher if chemical cleaning agents are also used. Technique is expected to be ineffective for fixed contamination. Waste - 4 to > 100 gpm of contaminated waste water.	Development - To minimize waste generation, a water treatment system is needed for decontamination of the wastewater so the water can be reused. Improvement - Remote operation will require adapting the high pressure water and vacuum collection systems to robotic system control.	Normal implementation needs. Development costs - waste treatment system: about $1.2M Remote operation:$3M - $4M Capital cost - $50K - $75K (about $250K with remote operation) Operating cost - $0.03-$1.00/sq. ft.
	Superheated Water DCON-53-OG	**Accepted** Technology is available and has been used by industry. Technology should be effective except for fixed insoluble contamination or contamination that has soaked into the substrate. Waste - 0.4 to 2.0 gpm wastewater containing removed contaminants.	Development - To minimize waste generation, a water treatment system is needed to decontaminate the water for recycling. Improvement - Remote operation will require adapting the superheated water and vacuum collection systems to robotic system control.	Normal implementation needs. Development cost - Water treatment system: about $1.2M Remote operation: $3M - $4M Capital cost - About $175K (about $250K with remote operation) Operating cost - $0.03 - $1.00/sq. ft.

Technology Lo

Decontamin

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Special Development Facilities	Plastic U S Cr	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Surf (con
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EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

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mination

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Surface Cleaning (cont'd)	Steam DCON-55-OG	**Accepted** The technique has proven useful, especially on comp;lex shapes and large surfaces. Technology should be effective except for fixed insoluble contamination or contamination that has soaked into the substrate. Waste - 0.4 to 2.0 gpm wastewater containing the removed contaminants	Development - To minimize waste generation, a water treatment system is needed to decontaminate the water for recycling. Improvement - Remote operation will require adapting the steam water and vacuum collection systems to robotic system control.	Normal implementation needs. Development cost - Water treatment system: about $1.2M Remote operation: $3M - $4M Capital cost - $50K - $75K (about $250K with remote operation) Operating cost - $0.03 - $1.00/sq. ft.
	Strippable Coating DCON-63-OG	**Accepted** This technology has been used for decontamination purposes in applications involving hazardous and/or radioactive contaminants. Efficacy - Decontamination factors of 100 to several hundred. Waste - 1 gallon of contaminated solid polymer /50 sq. ft.	Improvements - Potential area of improvement is reduction of material costs.	Capital cost - <$10K Operating cost - $2 - $2.4/sq. ft.
	Solvent Washing DCON-62-OG	**Conceptual** Solvent cleaning of small items has been used at K-25 and the cleaning of larger areas has been demonstrated at Richland. The use of solvent cleaning has been stopped at both sites to avoid exposing workers and the environment to the hazardous solvents. Other solvents may be available, but their effectiveness would have to be demonstrated. Efficacy - This method is only effective on smearable contamination. Waste would be spent solvent containing contaminants plus a trace of concrete.	Development-Solvents that are less harmful to health and the environment need to be identified and demonstrated.	Solvent off-gas collection and treatment system would be needed. Development cost - $1-4.5M Capital Cost: $400K (4K lb. unit) Operating Cost: $0.10 - $1.00/lb.
Chemical Surface Cleaning	Inorganic Acid Treatments DCON-12-OG	**Accepted** Decontamination with nitric acid has been used for cleaning converters and other large items at K-25 for many years. Sulfuric acid is used less often, notably to dissolve nickel plating prior to removing contaminants at the nickel-steel interface. The inorganic acids are concentrated, with concurrent corrosion. DFs are in the 100 range. Wastes consist of large quantities of corrosive wastes containing the removed contaminants and require treatment and disposal as mixed waste.	Development- Necessary to adapt modifications to the system (scrubbers, filters, treatment for nitrates and heavy metals) to recycle reagents to meet regulatory requirements. Science/Development- Possible development of the HNO_3/HF decontamination method, with or without ultrasonic agitation.	Normal implementation needs. Development cost: $400-1000K (Rough estimate) Capital cost: <$4-10 million (Rough estimate) Although existing facilities may be adaptable to the acid cleaning process, a treatment facility for corrosive nitrate wastes will be required. Operating cost: Similar to the other organic and inorganic treatment systems.

Technology Logi

Decontaminatio

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternati
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Special Development Facilities	<u>Plastic</u> U S Cr	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Decontamination	Bulk Decontami Methods

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram
tamination

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
→ Bulk Decontamination Methods	→ Incineration DCON-2-OG	→ **Accepted** Incineration is being used at K-25. A new incinerator would be needed because the existing incinerator cannot accept waste with more than 5 ppm total uranium and enrichments higher than one percent ^{235}U. Efficacy - The K-1435 incinerator gives 99.99 to 99.999% destruction and removal efficiency when burning toxic organics. Waste generated - This will depend on the design of the incinerator and the ash content of the waste being burned. During a test, the K1435 incinerator generated 1.1 gallons of wastewater and 27 pounds of ash per 100 pounds of waste fed.	→ None	→ A new incinerator would be needed to burn wastes contaminated with enriched uranium. The present incinerator requires the services of about 30 maintenance workers (maintenance mechanics, electricians, pipe fitters, welders, and instrument mechanics), their supervisors, 34 chemical operators, their supervisors, and 7 engineers. About 8-10 years is required for writing an environmental impact statement, holding public hearings, and obtaining the necessary permits - TSCA permit, RCRA permit, NESHAP permit, and Clean Air Act permits. Cost: capital cost $26 million (1987 dollars) Operation cost $10/lb (1992 dollars)

Dismantle

The Dismantlement section is written to address the K-25 Site problems spe f e
materials, major dismantlement (removal of equipment), disassembly of equipm er
approach is the assumption that dismantlement will not, in general, depend upo ub
tection are provided. Each section will explain the relationship of the subject to er
to follow a sequence similar to the current ongoing D&D efforts elsewhere.)

There are some basic assumptions for dismantlement including: (1) equipm a
(2) remaining, or vestigial, contamination will have been located and characteri e
ment will be sorted materials in forms suitable for disposal as recyclable scrap c
cle of materials will be desirable and/or required.

ntlement

ɔms specific to dismantlement: massive concrete, structural steel, asbestos
f equipment, and the need for other "enabling technologies." Basic to this
ɘnd upon the type of contamination as long as containment and worker pro-
ıbject to the dismantlement problem list. Dismantlement has been assumed
:re.
) equipment exteriors will have been decontaminated as much as practical,
·ıaracterized before dismantlement is initiated, (3) the products of dismantle-
ɔ scrap or waste or for disposition to complete decontamination, and (4) recy-

Technology Log

Dismantlem

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	-Alt
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Buildings Process Support Buildings Cooling Towers Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Electrical and Electrical Switch Gear	A.Massive Concrete	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Dismantlement	Concrete C Demolition

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Concrete Cutting	Abrasive Jet (High Pressure Water) DISM-11-OG	**Demonstration** This technology has been demonstrated but not at K-25 site. DOE sponsored development of Programmable Robotic manipulators. Water can be recycled. Concepts for abrasive recycling with 95% spoils recoverable: Battelle Pacific Northwest Laboratory has successfully demonstrated scarification and cutting of steel reinforced concrete. Successfully demonstrated at West Valley Nuclear Services, New York. Scarfing is used by DOT on bridges and is illustrated on video being used on the Mississippi Rive- ?ridge. (See Flow Inc Video).	Recovery System recyclable abrasives needs to be demonstrated. This will require portable facility if available or pools with necessary equipment to separate and possibly decontaminate the water and abrasive for reuse. The development of this equipment; manipulators for positioning on the floor, columns, and overhead: and cleaning pools for demonstration would cost $3.5M.	Need to view videos available from other nuclear facilities and possibly visit sites and evaluate recovery systems without on-site demonstration. Determine what robotics have been developed with in-house seminar from vendors on latest and future technology. Robotic manipulators with recovery system needs to be able to move around on floor, up and around concrete columns, and overhead (the underside of the floor above). Methods of addressing cracks in concrete, blow-through when cutting, containment of contaminated material, etc. will have to be made.
	Diamond Wire Cutting DISM-12-OG	**Demonstration** Diamond wire cutting has been used to cut concrete at other nuclear facilities except at ground level floors. Diamond wire cutting is an Industry accepted method but with heavy reinforced concrete will be a high maintenance item (diamond impregnated sleeves, cable and sheaves) and require water coolant for the cable. The waste generated will be less expensive. The slurry would be low level contamination or possibly no contamination. Positioning the core drilling equipment and the diamond wire cutting machine will be more difficult since there will probably be exposed reinforcing bar.	Track system for maneuvering core drilling machine and diamond wire cutting machine may be required. Exposed reinforcing bar will have to be manually cut in areas where cored holes are to be located to lower maintenance on saw. The development and installation of the track system and recovery system for demonstration will be $1.5M. The demonstration costs include personnel protection, clothing and storage but not transportation and burial charges. The demonstrations will have to be completed before a cost payback can be evaluated.	Determine what robotics have been developed with in-house seminars from vendors on latest and future technology and determine robotics needs. Track needs to be developed for demonstrations. Manipulators with vacuum systems need to be able to move in two directions. Vacuum systems will be needed on both sides of the floor being cut.
Demolition	Jackhammer, Headache Ball DISM-21-OG	**Demonstration** This technology has been demonstrated. And the wrecking ball is a demolition Industry accepted method but is not recommended for contaminated concrete such as exists in most DOE facilities. It is not practical to contain the dust and the reinforcing bar has to be cut by other means.	Vacuum systems to handle dust and small to medium pieces of concrete needs to be demonstrated. Crusher to down size concrete pieces needs to be demonstrated. The development and installation of the robotics and vacuums systems to handle dust and pieces of concrete and a crusher for demonstration would cost $1.5M.	Need to view videos available from other nuclear facilities and possibly visit other sites to evaluate multiple head hammer. Determine what robotics have been developed with in-house seminars from vendors on latest and future technology. Robotics need to be able to move around the floor, up and around concrete columns, and overhead. Demonstrations need to show how the corners and hard-to-get areas will be handled.

Technology Lo

Dismantle

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

- Enrichment Process Buildings
- Process Support Buildings
- Cooling Towers
- Pumping Stations
- Laboratory Facilities
- Special Development Facilities
- Administrative Facilities
- Electrical and Electrical Switch Gear

Problem Area/Constituents

A.Massive Concrete (cont.)

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelements

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Logic Diagram
ntlement

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Demolition (cont.)	Blasting DISM-22-OG	**Demonstration** This technology has been demonstrated and used by the demolition industry for years. Reinforcing bar has to be cut after blasting. Contaminated concrete will have to be removed by scabbling or scarfing. All walls and floor below ground level should not be disturbed until all debris has been removed and water level tests are complete.	Crane system for handling large sections of decontaminated concrete to crusher. Remote method of cutting reinforcing bar. Create method for installing lift rings for crane handling of large sections of debris or other methods of moving debris to crusher. Locate non-contaminated structure that will not have to be decontaminated. Demolish it with controlled blasting monitoring vibrations so that the system can be evaluated before actually being put into use. This demonstration on a non-decontaminated structure will be $200K.	Possibly watch and records actual site being demolished by controlled blasting. View videos from demolition companies and explosive manufacturers to see what method industry uses to cut reinforcing bar and remove large amounts of debris.
	Demolition Compounds (Expansive Grout) DISM-23-OG	**Demonstration** Effective on non-reinforced or lightly reinforced concrete. Any reinforcing bar will have to be cut by other means. The compound is not considered dangerous. Contamination control would not be a problem since the contamination will have already been removed by scabbling or scarfing. The demonstration would cost $500K. This demonstration cost includes personnel clothing and protection but not transportation and storage.	Use an uncontaminated building for a demonstration. The building would need to be with light or no reinforced concrete. Size, depth and pattern of holes would need to be determined. Method of cutting any reinforcing bar established. The fractured concrete would be removed with pavement breaker, backhoe or bucket loader. The dirt underneath the floor will have to be moved if necessary and decontaminated or stored.	Pattern, size depth and location of reinforcing bar need to be established. Means for cutting reinforcing bar and removing fractured section of concrete needs to be established. Crane facility and crusher to reduce concrete selection to eliminate and voids in storage. Before disturbing the walls that are underground or the ground level floors determine existence of wet weather springs to make sure removal won't create a stream running through contaminated rubble or a soil.
Surface Removal	Microwave Scabbling DISM-31-OG	**Pre-Demonstration** Microwave scabbling of concrete is in the final stage of phase 2 of a 4 phase program at ORNL. Phase 3 is scheduled for completion MID-1994. Phase 3 will develop improved mobility. Remote video control, vacuum waste collection and remote controlled capabilities. Phase 4 will design vertical and overhead scabbling as well as optimizing the proper methods and configurations for cleaning the off-gas discharged by the vacuum system. All ANSI and OSHA standards will be met or exceeded. Microwave scabbling was demonstrated.	The development has already been funded (see TTP. NO OR-3DAA). The demonstration costs includes characterizing walls and floor, identifying reinforcing steel grid pattern, building portable containment enclosures, personnel protection, clothing, installation and demonstration of the Phase 3 advanced stage microwave machine, robotics, and vacuum system will be $3M. The phase 2 demonstration costs includes characterizing walls and floor, identifying reinforcing steel grid pattern, building portable containment storage, but not transportation and burial charges. The development and installation of the Phase 4 system for demonstration will be $5M.	Create a demonstration program for the most advanced system for all alternatives so a true comparison can be made. Track system, if required, needs to be developed for demonstration. Manipulators with vacuum systems need to be able to move along floor, around columns, up walls, and overhead. Microwave drying being developed at ORNL possibly could be used to consolidate and immobilize liquid radioactive waste inside containers for ultimate safe disposal, but needs demonstration.

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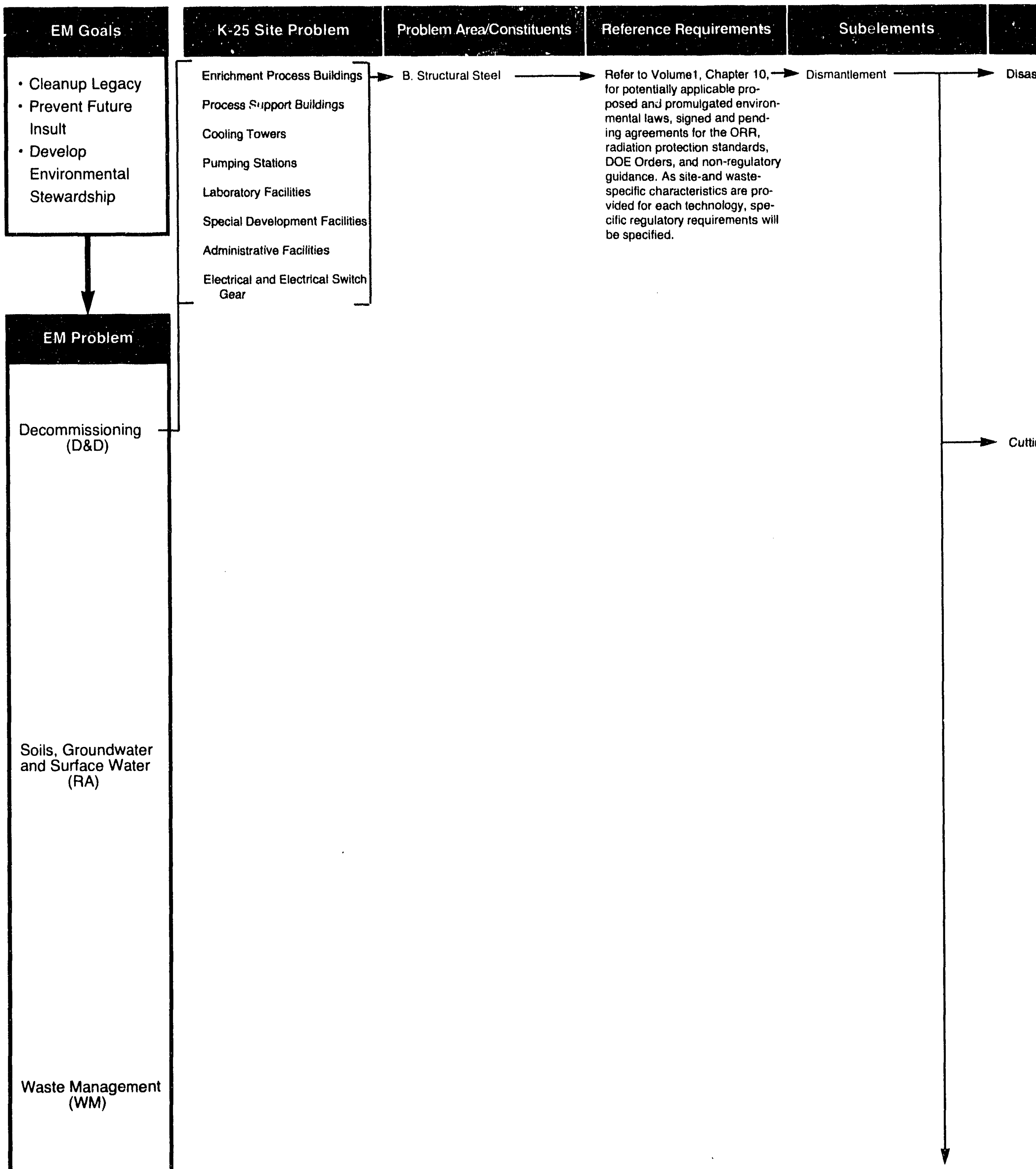

Disassembly	Qualitative IR Thermography to detect cracks in steel beams, unrecorded variations in wall construction, beam/wall discontinuities, or soaked roofing subsurface. DISM-32-OG	**Pre-demonstration** Advantage: inexpensive, portable, noninvasive, passive measure. Realtime or VCR/Still imaging, reasonable compact apparatus (roughly 6 ft^3). Excellent, initial gross detection method. Disadvantages: image often requires trained interpretation. Emissivity differences and/or local spurious infrared sources may complicate image analysis. Generation of spent inert nitrogen gas may complicate operation in tight confined space. Outdoor measures may be weather dependent.	Requires natural or applied transient or steady-state heating. Method works best with IR-Flat background.	ATD's 2 AGA systems require liquid nitrogen and should not be used in a high shock environment. Only a few hours of sampling time battery charge, although AC power, is also available. Remote or robotic operation possible but not demonstrated. Need to implement current technology system - cost ~$110K.
	Conventional Disassembly (mechanical) - Mechanical cutting, saws, grinders, etc. DISM-33-OG	**Accepted** Mechanical cutting is accepted. Industry standard needs no further development.	None.	Needs to be demonstrated with appropriate remote platform interface.
Cutting	Nd:YAG on CO_2 Laser Cutting (removal of major components from the cascade). DISM-34-OG	**Pre-demonstration** Technology exists in the predemonstration stage at the Penn State Applied Research Laboratory (ARL). The U.S. Navy has funded feasibility demonstration of the technology for dismantlement of submarine hulls. The technology is very likely to work since laser cutting is common in industry.	Laser cutting using a laser carried through a fiber-optic cable or waveguide requires demonstration. Current fiber-optic cables cannot efficiently transmit the wavelengths generated by a CO_2 laser.	Tooling to interface the laser cutting head with the automated delivery platform needs to be designed and demonstrated. A demonstration is required on simulated equipment for the K-25 type facility and the K-33 type facility, projected cost: $3.1M.
	Abrasive Water Jet Cutting DISM-35-OG	**Demonstration** Abrasive water jet cutting is a demonstrated technology. Advantages of this type of cutting are: 1. The system is flexible and can cut many different materials. 2. No sparks are generated reducing fire hazards. Disadvantages of the abrasive water jet cutting are: 1. Large amounts of water must be recovered. This water would likely be contaminated with uranium and PCB'S. 2. Dependent on the material being cut. depth of cut is limited. 3. This would be considered a high pressure system raising safety concerns.	Technology needs recovery system and recyclable abrasives.	The ability to separate contamination from the water slurry would have to be demonstrated. Otherwise, large quantities of contaminated water would be generated making the process undesirable.

Technology Lo L

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Buildings Process Support Buildings Cooling Towers Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Electrical and Electrical Switch Gear	B. Structural Steel (cont.)	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Dismantlement	Cutting (cont.)

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Cutting (cont.)	Plasma Arc cutting. DISM-36-OG	**Demonstration** Plasma ARC cutting is an accepted technology in industry and needs no further development. 1. Plasma ARC cutting are usually mobile and thus, can be transported to the job site. 2. Cutting can be performed on equipment in-place. 3. The system is relatively inexpensive. Disadvantages of the system are: 1. Airborne contamination will be generated that will settle on equipment below the cutting site. 2. Uranium contamination may be alloyed with the structural members being removed thus making decontaminating significantly more difficult.	Need for making process continuous and computer assisted have been cited.	HEPA filtered exhaust system and a contained area for use when cutting contaminated material are needed.
	Arc Saw Cutting DISM-37 OG	**Accepted** Current arc method for cutting conducting work pieces. Advantage of fast cutting. Disadvantages of not usable for all materials and thick cuts may require repeated passes.	None	Ventilation required if not operated under water. Blade requires water cooling.
	Oxygen Cutting DISM-38-OG	**Accepted** Well understood usable approach but has some material limitations and can be labor intensive.	N/A	Exhaust ventilation required.
	Plasma Arc Saw - this new technological development allows thermal cutting of steel with wall thickness up to 300 mm tubes, bank of tubes and geometric complicated components. Also, this technology can be used under water up to a depth of 20 meters. With a normal plasma torch it is not possible or at least extremely difficult. DISM-40-OG	**Demonstration** The Plasma Arc Saw technology enables thermal cutting of steel plates/walls independent of its thickness in a water depth up to 20 meters. This technology was demonstrated in cutting plates up to a thickness of 300 mm. The maximal permissible metallic wall thickness to be cut depends only on the diameter of the saw (plasma-arc) blade. The emission of dust and aerosol during the process, only depends on the melted material. This process is controlled by computers.	For large steel wall-thickness (>100 mm - requires the development of the large saw and re-runs in the process.	Requires transfer from development stages (prototype - 1990) to broad industrial application. Technology is available in commercial basis.
	Thermal arc-waterjet - with this thermal arc waterjet cutting device it is possible to cut steels up to a wall thickness of 100 mm underwater up to 20 meters. The cutting process is based in an electric arc between the wire electrode and the metal sheet. Thus melting the metal in the work piece. The waterjet around the wire is used to "wash-a-way" the melted material from the cutting kerf. The wire is consumed because of the high current. The wire has to be fed so that the process can work continuously. DISM-41-OG	**Demonstrated** Demonstrated technology of cut metallic parts/walls up to 100 mm thick and up to 20 meters underwater. This thermal arc-waterjet cuts are in general, directed by computer numeric controller. With additional tooling support, cutting in several axis of operations, will be possible. Hole piercing up to a wall thickness of 30 mm could be done also. Cutting in vertical and horizontal motion. Pipes bank of pipes and geometrical complicated components, is possible.	No additional basic development necessary.	Required possible pre-runs to accommodate the arc waterjet cutter to possible room/space shortages in the working area. In general, no major changes on the cutter device is needed. Commercially available technology.

Technology Log

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alter
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Buildings Process Support Buildings Cooling Towers Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Electrical and Electrical Switch Gear	B. Structural Steel (cont.)	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Dismantlement	Cutting (cont.) Demolition

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Cutting (cont.)	Advance-Lasers for Cutting DISM-42-OG	**Pre-demonstration** Feasibility demonstration at university laboratory in Navy-funded project. Laboratory demonstrated efficient cutting through steel pf up to 4-in. thickness. Technology lends itself well to tele-robotic/automated process, has low waste, can greatly reduce manpower,and reduce waste elimination. Advanced lasers have potential for reduced power requirements, use for other D&D applications ((decontamination), and remote location. Cost savings potential is large ($800M to $1.2B) relative manpower, protective clothing, and waste handling reductions.	Demonstrated efficacy of fiberoptic system for either local or remote transport of laser beam. Demonstrate effect on contamination. Determine power level needs and scale-up potential of new systems. Develop integrated delivery system.	Develop full-scale prototype system ($800K to $1,000K) and field test ($10 million) in K-25 or K-33-type facilities. Evaluate system economics.
Demolition	Grabbler for Remotely Cutting Metals (Massive Shearing). DISM-56-OG	**Demonstration** The technology is not available at K-25 but has been demonstrated at other sites. This device would cut through metals using a remotely controlled arm with a shearing mechanism attached. The grabbler would be mobile so that it could move to the job site.	The grabbler concept needs to be for the scale of operation required. New technologies are likely not needed. Development would primarily involve mechanical design and robotic control design. Estimated cost: $10M	The grabbler would have to be demonstrated at a K-25 type of facility. Safety of the equipment would likely have to be assessed and documented.
	Explosive Cutting - An explosive cutter consists of an explosive core contained in a metal or hard plastic casing. The cutter is chevron shaped, so it can be directed at the workpiece. This technique can be used either in air or under water. Cutting speed is a function of how fast the charges can be placed; this process can cut metals up to roughly 6 inches thick. DISM-44-OG	**Demonstration** This technology is accepted as a means of gross cutting. Capital cost of this system, in 1989 dollars, was small. Charges and cutters are consumable; charges cost$150/ft. and cutter $8K each.	A means of buffering the shock wave and its associated noise is needed.	This process is not recommended for contaminated metals because it would be extremely difficult to control the spread of airborne contaminants. Robotics: charges can be placed remotely.
	Thermite Cutting - When iron, aluminum, and magnesium are ignited together, they react ("thermite reaction") producing temperatures up to 10,000 F. Oxygen is forced through a lance, thus the oxygen and wires can then be lit and the torch directed by the operator. The amount of oxygen controls the flame. The system is portable, but requires an operator to be close to the cutting. The torch can be used underwater. DISM-45-OG	**Pre-demonstration** The thermite reaction is well known and understood by the thermite lance (an accepted technology) is a gross cutting tool not suitable for toxic materials. Hazards include spatter of hot metal, noise, metal fumes and dust. In 1989 dollars, the capital cost for the system was $555. Lances cost $5 each; oxygen cost must also be added.	The thermite reaction needs to be incorporated into a process that can be remotely controlled to be useful in contaminated environments.	Exhaust ventilation is required with this system, as well as enhanced safety awareness because of the fire hazard created by the system.

Technology Lo

Dismantle

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
Enrichment Process Buildings Process Support Buildings Cooling Towers Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Electrical and Electrical Switch Gear	C. Asbestos Removal	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Dismantlement	Strippin Cutting

Stripping	Vacuum System - the vacuum system is self-contained and mounted on a towable trailer. The system includes a hopper, bagging port, HEPA filter, Self-powered vacuum system, and large diameter suction hose is routed to the asbestos removal area and transports the asbestos to the hopper to the removal point that can be up to 1000 ft away. DISM-46-OG	**Accepted** The technology is currently available and is in the use at the ENERGY SYSTEMS Y-12 Plant Site in Oak Ridge, TN. This system would save approximately 250% in the cost of materials and labor over the conventional removal and glovebag operation. An example of cost saving is an area requiring 11 laborers and 4000 bags using the conventional method would require 4 laborers and 1500 bags using the proposed automated method.	None required. However, this could be integrated with alternative highly automated systems in which case it would require additional engineering design support.	Operator training required on the system set-up and operation.
	CO_2 Blasting - High Pressure CO_2 blasting is ultra high pressure CO_2 that is forced through a small diameter nozzle that creates a spray that cuts away the surface of material. The contaminated surface removed will be handled as waste. The remaining pipe can then be cut up by other methods and recycled, reused, or disposed of locally. The technology is currently available but has not been demonstrated at the ENERGY SYSTEMS Oak Ridge K-25 Plant. DISM-47-OG	**Demonstration** DOE Sponsored development; programmable robotic manipulators have been developed; high maintenance items: nozzles, hoses, and pumps. CO_2 blasting has been demonstrated but not at the K-25 plant site. By removing the contaminated surfaces which will be bagged and disposed of, the remainder of the decontaminated pipe can be recycled or reused. This will save $17.00 cu-ft for disposal. Demonstrations for removing need to be completed before cost-payback can be evaluated. The recovery system would be well suited for contaminated piping.	Vacuum recovery system linked to robot controlled CO_2 blaster needs to be demonstrated. The development of this equipment; manipulators for tracking pipe during removal, remote operated robotic manipulators and an integrated vacuum system for demonstration would cost $3.5M. The demonstration cost includes personnel protection, clothing and container storage but not transportation and burial charges.	Need to view videos available from other nuclear facilities and possible visit sites and evaluate recovery systems without on-site demonstration. Determine what robotics have been developed with in-house seminar from vendors on latest and future technology. Robotic manipulators with recovery system needs to be able to move around on floor, up and around concrete columns, and overhead (the underside of the floor above). Methods of addressing removal of asbestos from valves in piping. Piping elbows, and piping very close to walls will have to be made.
	Glassification - Glassification is accomplished by taking a predetermined size of material and encasing it inside of glass. The size of the refuse can be linked to a machine that is capable of reducing larger pieces of asbestos refuse so that it can be run thru the glassification process. After glassification the fibers of the asbestos would be encased and could virtually eliminate air-borne particles of asbestos during shipping. DISM-48-OG	**Demonstration** Technology currently available however, it has not been tested at the K-25 plant site.	Need feasibility and design engineering to interface a confined environment machine equipped with a vacuum recovery system to process large pieces of asbestos into workable configurations. A study will need to be done to determine if this would create any new, unrecognized waste control or disposal problems. The development of this equipment; cutter, shredder or grinder, for demonstration would cost $3.5M.	Need to view videos available from other nuclear facilities and possibly visit sites and evaluate recovery systems without on-site demonstration. Determine what robotics have been developed with inhouse seminar from vendors on latest and future technology.
Cutting	Laser Cutting - Advanced laser for cutting of asbestos materials - laser cutting is accomplished with a laser beam which thermally sears thru the asbestos and cuts it into pieces easily handled for disposal. This method would be used to cut the transite panels from around the diffusion equipment. Laser manipulator could include either grippers or suction cups to safely remove and stack pieces during and after they have been cut. DISM-49-OG	**Pre-demonstration** DOE sponsored development; programmable robotic manipulators have been developed. Laser cutting of asbestos has had laboratory feasibility demonstration. Preliminary results indicate that cutting of material results in essentially no dispersement of fibers and leaves the asbestos cut interface cauterized. Thus helping seal the surface and prevent dispersement of fibers during handling, ND:YAG-Type lasers should have sufficient power and can be coupled with a fiber-optic delivery system for ease of adapting to automated systems and for improved safety.	Need confirmation of negligible asbestos dispersement and cut cauterization. Beam containment, laser safety, optics protection from flaming, etc., are issues to be addressed during development. The key issue is to substantiate that fusion of fibers occurs and does not create any new. Unrecognized waste control or disposal problems. The development of this equipment; manipulator track for laser; and grippers or holding devices for cut material for demonstration would cost $3.5M.	Need to view videos available from other nuclear facilities and possibly visit sites and evaluate recovery systems without on-site demonstration. Determine what robotics have been developed with inhouse seminars from vendors on latest and future technology. Robotic manipulators with recovery system needs to be able to move around on floor, up and around concrete columns, and overhead (the underside of the floor above).

Technology Logi

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EM Goals	EM Problem
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Decommissioning (D&D) Soils, Groundwater and Surface Water (RA) Waste Management (WM)

K-25 Site Problem

- Enrichment Process Buildings
- Process Support Buildings
- Cooling Towers
- Pumping Stations
- Laboratory Facilities
- Special Development Facilities
- Administrative Facilities
- Electrical and Electrical Switch Gear

Problem Area/Constituents	Reference Requirements	Subelements	Alternati
C. Asbestos Removal (cont.)	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Dismantlement	Cutting (cont.)
D. Major Dismantlement	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Dismantlement	Cutting, Advanced
Electrical Equipment (PCB Contaminated)	TSCA FFCA • Complete disposition of PCB electrical equipment. 9/94		
Ventilation System (PCB Contamination)	TSCA FFCA • Complete PCB Ventilation gasket removal from K-29, K-31, K-33, 8/2001 • Complete dispoal of PCB waste. 12/2015		

Logic Diagram

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Cutting (cont.)	High Pressure Abrasive Water Jet Cutting - abrasive waterjet removal is ultra high pressure water with and without abrasive that is forced through a small diameter nozzle that creates a spray that cuts away the surface of material. The contaminated surface removed will be handled as waste with the contaminated abrasives and water to be recycled. The remaining pipe can then be cut up by waterjet cutting or other methods and recycled, reused, or disposed of locally. The technology is currently available but has not been demonstrated at the ENERGY SYSTEMS Oak Ridge K-25 Plant. DISM-50-OG	**Pre-demonstration** DOE sponsored development; programmable robotic manipulators have been developed; water can be recycled. Concepts for abrasive recycling with 95% spoils recoverable; high maintenance items; nozzles, hoses, and pumps when abrasives are used. Metal demonstrated but not at the K-25 plant site. High efficiency recovery system a must for removal to keep contaminated run off to a minimum. Cracks in concrete will be a problem since contamination will still be present and will have to be addressed. But no one system will be ideal for every situation.	Recovery system with recyclable water abrasives needs to be demonstrated. This will require a portable facility if available or pools with necessary equipment to separate and possibly decontaminate the water and abrasive for reuse. The development of this equipment - manipulators for tracking pipe during removal, holding pipe during cutting, lowering pipe after cutting, and cleaning pools for demonstration - would cost $3.5M. The demonstration cost includes: building portable containment enclosure, personnel protection, clothing and container storage but not transportation and burial charges.	Need to view videos available from other nuclear facilities and possibly visit sites and evaluate recovery systems without on-site demonstration. Determine what robotics have been developed with in-house seminar. Robotic manipulators with recovery system needs to be able to move around on floor, up and around concrete columns, and overhead (the underside of the floor above). Methods of addressing cracks in concrete, below material, water, and possibly abrasives, removal of asbestos from valves in piping, piping elbows, and piping very close to walls will have to be made.
Cutting, Advanced	Nd: Yag and CO_2 Laser Cutting - (Removal of major components from the cascade). DISM-51-OG	**Pre-demonstration** Technology exists in the pre-demonstration stage at the Penn State Applied Research Laboratory (ARL). The U.S. Navy has funded feasibility demonstration of the technology. It is very likely to work since laser cutting is common in industry.	Laser cutting using a laser carried through a fiber optic cable or waveguide requires demonstration. Current fiber optic cables cannot efficiently transmit the wavelengths generated by a CO_2 Laser.	1. Tooling to interface the laser cutting head with the automated/robotic delivery platform needs to be designed and demonstrated. 2. A demonstration is required on simulated equipment for the K-25 type facility and the K-33 type facility. Projected cost: $5 Million.
	High Pressure Abrasive Water Jet. Abrasive water jet cutting, with or without abrasives, is ultra high pressure water that is forced through a small diameter nozzle that creates a steam that cuts through metal. The contaminated parent material that's removed will be segregated and handled as nuclear waste with the contaminated abrasives and water to be recycled. The blow through will have to be contained by shrouds attached to a high efficiency vacuum system with any other overspray, etc., contained in a pool. The shrouds will have to be designed for specific application with the containment pools being portable. DISM-52-OG	**Demonstrated** Abrasive waterjet cutting development was DOE sponsored. Programmable robotic manipulators have been developed. Water and abrasives can be recycled with 95% spoils recoverable. Any recyclable material accumulated will save $20.00 cu-ft for disposal.	Abrasive waterjet cutting technology exists but high efficiency vacuum recovery and mobile containment system will need to be further developed with the shrouds., etc. designed for a specific application for a demo. A state of the art demo would cost 3.5M and would not include transportation or burial charges. The results of 7/92 estimates there are 200K tons of structural steel in the K-25 "U" building alone. There is over 3.6M lbs of nickel in K-33. There is over 1.2M lbs of copper in the K-33 motors alone. Most of this material can possibly be recycled with state of the art disassembly and decontamination techniques.	Develop state of the art system for demo on specific equipment. Develop market for massive amounts of recyclable steel, copper, etc.
	Advanced Lasers for Cutting DISM-53-OG	**Pre-demonstration** Feasibility demonstration at Penn State University laboratory in a Navy-funded project. Lab-demonstrated efficient cutting through steel of up to 4-in. thickness. Technology lends itself well to tele-robotic/automated process, has low waste, can greatly reduce manpower, and reduce waste elimination. Advanced lasers have [potential for reduced power requirements, use for other D&D applications (decontamination), and remote location. Cost savings potential is large ($800M to $1.2 B) relative to manpower-intense approaches (manpower, protective clothing, and waste handling reductions).	Demonstrate efficacy of fiberoptic system of either local or remote transport of laser beam. Demonstrate effect on contamination. Determine power level needs and scale-up potential of new systems. Develop integrated delivery system.	Develop full-scale prototype system ($800K to $1,000K) and field test ($7.0 million) in K-25 or K-33-type facilities. Evaluate system economics.

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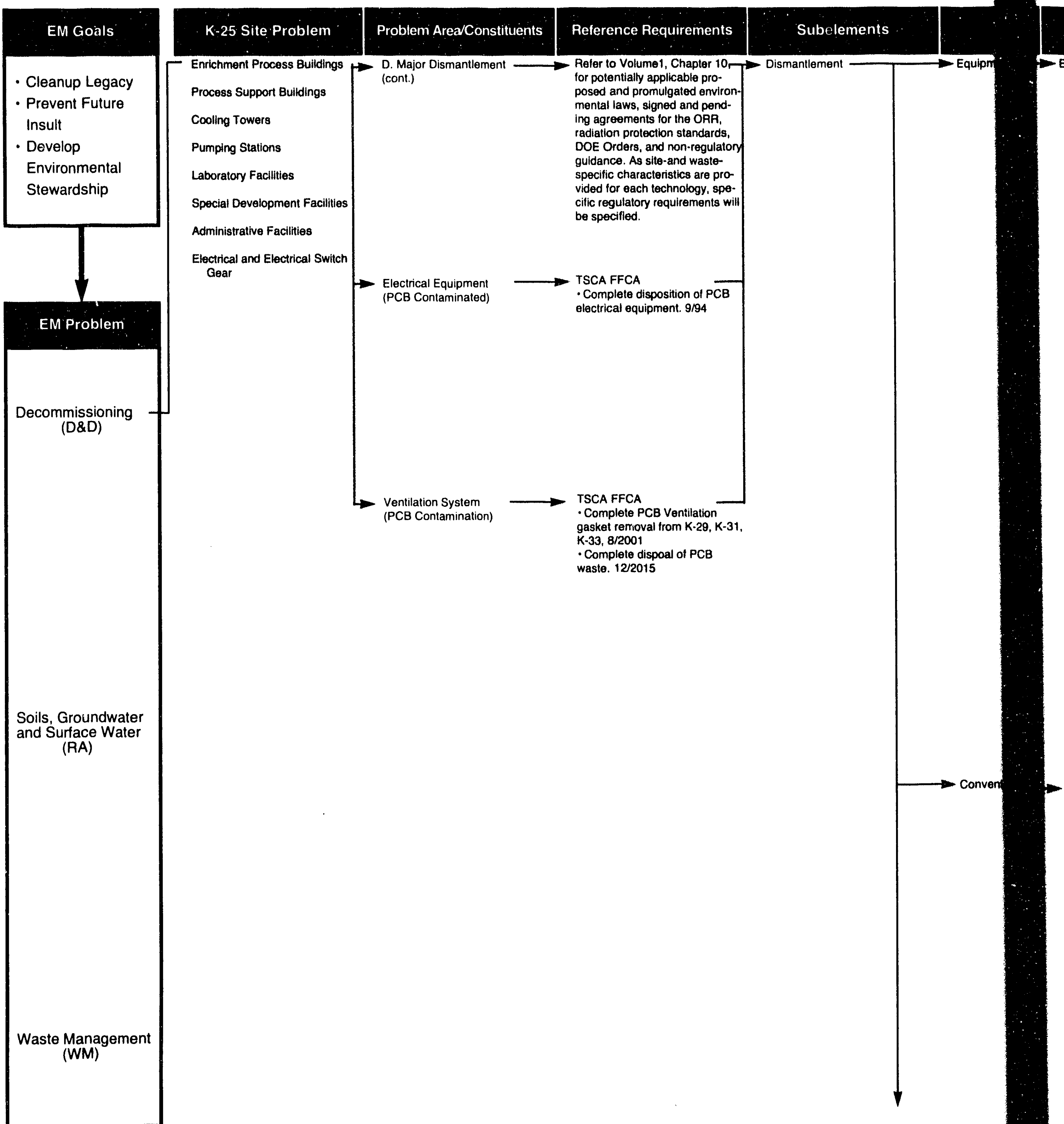

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Equipment Location	Positioning of Equipment Using Laser/Bar Codes DISM-54-OG	**Demonstration** Technology exists to precisely position equipment such as warehouse stacker cranes using bar codes attached to permanent building features such as columns. The Caterpillar Company currently markets such a system. Assuming the philosophy of dismantlement is the automatic dismantlement of systems using robotic tool delivery platforms, when this technology will be directly applicable to our problem. This technology could save a large amount of funding depending upon the philosophy of dismantlement assumed.	No major development needed.	Major demonstration will be required to identify the detailed criteria for such a system. This demonstration would cost $5-7M but could be a part of any integrated dismantlement demonstration. If integrated into another demonstration the cost would be minor ($90 - 120 Thousand).
	Zoning for Containment (3 Zones) DISM-55-OG	**Accepted** Containment to prevent spread of exposed contamination to less contaminated areas has been demonstrated to be an effective cost reduction tool. At the Mound Laboratory facility a technique involving 3-Zones, "Cold, Buffer, and Hot" is being used to isolate contamination. Temporary containment has been shown to prevent increasing contamination in the surrounding building when removing gloveboxes. This technology will be necessary during dismantlement. It will allow an estimated 80 - 90% of the materials to be removed to be treated as low level waste. Commercial suppliers are available. Cost savings would result from reduction of disposal cost for 80 - 90% of the material in the diffusion facilities. Low level waste can be disposed at $20/cu-ft. Material exceeding the limits for low level cost approximately $100/cu-ft to dispose. Assuming all building materials can be disposed as low level waste the savings would be $1-2 Billion for the older buildings.	Lighter weight materials such as honeycomb construction may make panels easier to handle and cheaper. Inflatable panels may be applicable.	Panels need to be engineered to allow reuse of panels in the next dismantlement zone. Design for enhanced fire protection design. Flammable materials would be prohibited.
Conventional	Use of Existing Fixtures for Thermal Cutting DISM-56-OG	**Accepted** Technology exists in each of the diffusion plants that permits the removal of major components without new equipment. The methods and equipment have been proven and have been in use for over 40 years.	The equipment that was used to remove Gaseous Diffusion Equipment from the Cascades would require removal from storage. When this group of jigs and fixtures have missing parts the existing design drawings would be required to fabricate and replace needed components.	All jigs and fixtures would have to be located and if necessary retrofitted to restore them to working condition. Existing jig and fixture fabrication drawings would need to be recalled from archives where necessary.

Technology Logic

Dismantlement

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternatives
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Buildings Process Support Buildings Cooling Towers Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Electrical and Electrical Switch Gear	D. Major Dismantlement (cont.)	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Dismantlement	Conventional (cont.)
		Electrical Equipment (PCB Contaminated)	TSCA FFCA • Complete disposition of PCB electrical equipment. 9/94		
		Ventilation System (PCB Contamination)	TSCA FFCA • Complete PCB Ventilation gasket removal from K-29, K-31, K-33, 8/2001 • Complete dispoal of PCB waste. 12/2015		Demolition

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Conventional (cont.)	Advanced Automatic Fixtures, Bug - O, etc. DISM-57-OG	**Accepted** The cascade improvement program completed in the early 1980's for the diffusion facilities used automated positioning tools for cutting and welding to modify steel components including converter shells. This same tool concept can be adapted to cutting in the cascade assuming the appropriate delivery system. The technology is a certainty to work for cutting round piping such as diffusion cascade piping. Careful attention will need to be paid to shrouding the area where the cut is taking place to avoid spread of airborne contamination. The technology can achieve increased efficiency of manpower and safety. Cost savings of 50% to 70% could be achieved over the 15-20 man-hours per cut on 30 in. piping. This would translate to a savings of up to $20 million for one major facility alone.	Science needs - None. Development needs - None. Improvement needs - A significant demonstration of a prototype will be required in the actual environment of the prototype will be required in the actual environment of the diffusion cascade. The demonstration would need to define the best way to power and control the tooling in a remote operating mode. Integration with a robotic deliver platform would significantly compound the total benefit. savings of 5-10 times those stated under "Status" could be realized.	Roughly a man year of design would be required to design a prototype (90K). The total hardware cost would be approximately $100K in 1992 dollars. No significant software is required although interlocking with any robotics would be necessary and may require approximately .5 man years to design. No facilities are needed over those existing in Oak Ridge. Re-activation of one crane bay in K-33 would be beneficial in that actual testing on diffusion piping could occur. The total cost of a prototype demonstration would be about $1.5M. The tooling would then be duplicated. Approximately 20 different sizes would be required resulting in a total procurement cost of $500K for the three larger facilities, Assuming each costs $25,000. The older facilities would require approximately 30 different sizes at a total cost of $450K for K-25 and K-27 of each costs $15K.
	Plasma Arc Cutting. DISM-36-OG	**Demonstration** Plasma ARC cutting is an accepted technology in industry and needs no further development. 1. Plasma ARC cutting are usually mobile and thus, can be transported to the job site. 2. Cutting can be performed on equipment in-place. 3. The system is relatively inexpensive. Disadvantages of the system are: 1. Airborne contamination will be generated that will settle on equipment below the cutting site. 2. Uranium contamination may be alloyed with the structural members being removed thus making decontaminating significantly more difficult.	Need for making process continuous and computer assisted have been cited.	HEPA filtered exhaust system and a contained area for use when cutting contaminated material are needed.
Demolition	Grabbler/Gross Shearing and Lifting. DISM-58-OG	**Demonstrated** Commercially available technology exists to adapt large hydraulic excavator - mounted shearing jaws and grabbing devices to readily available earth moving equipment. This technique has been used at the Apollo Penn D&D project to remove structural steel from the former NUMEC fuel fabrication plant.	No new science is needed.	A major demonstration of this technology will be required to determine the extent of airborne contamination generated for a typical cut into the diffusion piping. Cost of such a demonstration will be $2-3M. Cost may be shared with a demo for asbestos, structural steel, massive concrete. The cost to implement the concept would be $300-500K/ if the demonstrations successful. Robotics will be useful if the excavator arm were to be operated remotely, either teleoperated or umbilical.

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EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Deveiop Environmental Stewardship

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

K-25 Site Problem (Decommissioning (D&D))

- Enrichment Process Buildings
- Process Support Buildings
- Cooling Towers
- Pumping Stations
- Laboratory Facilities
- Special Development Facilities
- Administrative Facilities
- Electrical and Electrical Switch Gear

Problem Area/Constituents	Reference Requirements	Subelements	
E.Disassembly of Major Components	Refer to Volume 1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Dismantlement	Cutting
Electrical Equipment (PCB Contaminated)	TSCA FFCA • Complete disposition of PCB electrical equipment. 9/94		
Ventilation System (PCB Contamination)	TSCA FFCA • Complete PCB Ventilation gasket removal from K-29, K-31, K-33, 8/2001 • Complete dispoal of PCB waste. 12/2015		

Cutting, Advanced

Cutting, Advanced	High Pressure Abrasive Water Jet Cutting of Steel. Abrasive water/jet cutting, with or without abrasives is ultra high pressure water that is forced through a small diameter nozzle that creates a stream that cuts through metal. The contaminated parent material that's removed will be separated and handled as nuclear waste with the contaminated abrasives and water to be recycled. The blow through will have to be contained by shrouds attached to a high efficiency vacuum system with any other overspray contained in a pool. The shrouds will have to be designed for specific application with the containment pools being portable. DISM-59-OG	**Demonstration** Abrasive waterjet cutting development was DOE sponsored. Programmable robotic manipulators have been developed. Water and abrasives can be recycled with 95% spoils recoverable. Any recyclable material accumulated will save $20.00/cu-ft on disposal.	Abrasive waterjet cutting technology exists but high efficiency vacuum recovery and mobile containment system will need to be further developed with the shrouds, etc./designed for a specific application for a demo. A state of the art demo would cost $3.5 M not including transportation or burial charges.	Develop state of the art system for demo on specific equipment. Develop market for massive amounts of recyclable steel, copper, etc.
	High Pressure Water Jet: Previously used to disassemble converters in the late 1970's and early 1980's. Capabilities already exist. DISM-60-OG	**Accepted** High pressure water jet fully developed. Some equipment may still be available at the site.	None	Modifications may exist for current regulatory concerns. Schematic layout and representation need to be addressed.
	With Thermal Arc Water Jet Cutting it is possible to cut steels up to a wall thickness of 100 mm. The cutting process is based on an electric arc between the wire electrode and the metal sheet, thus melting the metal in the work piece. The waterjet around the wire is used to "wash-away" the melted material from the cutting kerf. The wire is consumed because of the high current. The wire has to be fed so that the process can work continuously. DISM-61-OG	**Demonstration** Technology cuts metallic parts/walls up to 100 mm thick and up to 20 meters underwater. This thermal arc waterjet cuts are, in general, directed by computer numeric controller. With additional tooling support, cutting in several axes of operations will be possible. Hole piercing up to a wall thickness of 30 mm could be done also. With cutting in vertical and horizontal motion, pipes, banks of pipes, and geometrical complicated components cutting is possible.	No additional basic development necessary.	Required possible pre-runs to accommodate the arc waterjet cutter to possible room/space shortages in the working area. In general, no major changes on the cutter device are needed. Commercially available technology, at least in Germany.
	Plasma Arc Saw. This new technological development allows thermal cutting of steel with wall thickness up to 300 mm. tubes, bank of tubes and geometric complicated components. Also, this technology can be used under water up to a depth of 20 meters. With a normal plasma torch it is not possible or at lease extremely difficult. DISM-62-OG	The plasma arc saw technology enables thermal cutting of steel plates/walls independent of thickness in a water depth up to 20 meters. This technology was demonstrated in cutting plates up to a thickness of 300mm. The maximal permissible metallic wall thickness depends only on the diameter of the saw plasma-arc blade.	Large steel wall thickness (>100mm) requires the development of the large saw and re-runs in the process.	Requires transfer from development stages to broad industrial application. Technology is available in commercial basis.

Technology Logic

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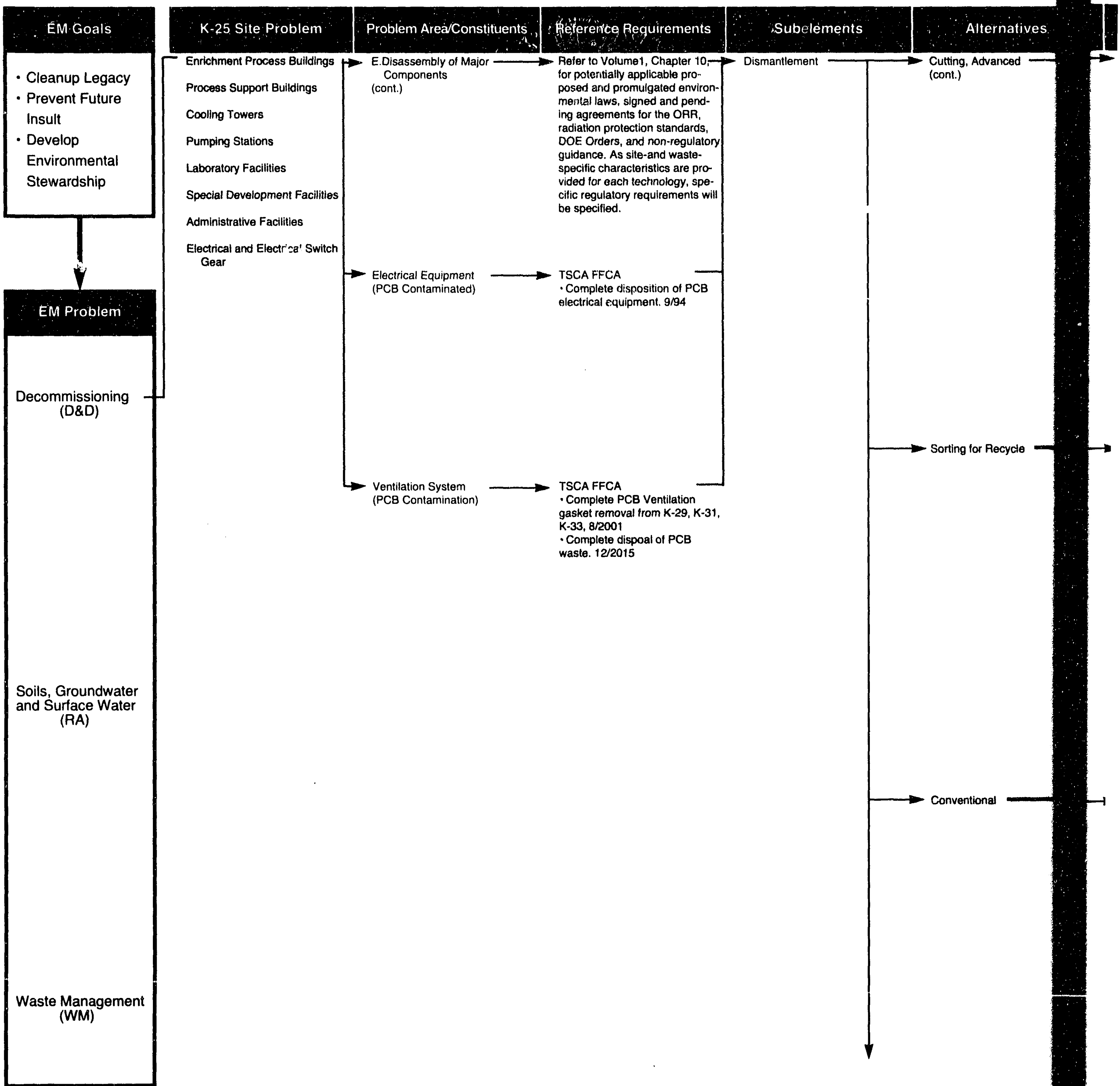

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Cutting, Advanced (cont.)	Nd:YAG and CO2 Laser Cutting. DISM-63-OG	**Pre-demonstration** Technology exists at the Penn State Applied Research Laboratory (ARL). The U.S. Navy has funded feasibility demonstration of the technology for dismantlement of submarine hulls. The technology is very likely to work since laser cutting is common in industry. Cost savings of $200M to $300M in reduction of labor and protective clothing. A fiber optic or other waveguide delivery system is preferred but has not been demonstrated.	Laser cutting using a laser carried through a fiber-optic cable or waveguide requires demonstration. Current fiber-optic cables cannot efficiently transmit the wavelengths generated by a CO_2 laser.	1. Tooling to interface the laser cutting head with the automated delivery platform needs to be designed and demonstrated. 2. A demonstration is required on simulated equipment for the K-25 type facility and the K-33-type facility. Projected Costs: $5.0 M.
	Liquefied Gas Cutting: Liquefied gas would be used in a manner similar to water jet cutting (author's opinion). The advantage to to such a system would be similar to CO2 blasting in that removed or cut materials would be lifted from the surfaces involved by the evaporating gas with very little surface abrasion to trap contamination. DISM-64-OG	**Evolving Technology** Advantages may be achieved due to the low temperatures involved. Cutting below the embrittlement temperature for metals may be beneficial. Cost advantages would be realized in cutting equipment where criticality safety is a major issue. This is an issue in the 1940's vintage equipment. This technique could save 20% of the cost over abrasive water jet cutting.	Cooperative effort with commercial suppliers of jet cutting and blasting equipment must be initiated to investigate this technology. The Hanford Wiring states that there is "No known program".	Full engineering and development needed. Cost to implement estimated at $10 million.
Sorting for Recycle	Shredding and Sorting DISM-65-OG	**Pre-demonstration** Technology exists in commercial areas to shred and automatically sort materials including sheet metal equipment (automobiles and appliances) for various purposes. Commercial vendors have supplied shredders to both the X-10 and Y-12 facilities in Oak Ridge for these purposes. **Efficacy:** The application of this technology will require testing of large shredders capable of handling items with the structural integrity of an axial flow diffusion compressor. **Cost Benefits:** This technology could provide a savings of an estimated 20 hours per component. For K-33 alone this would be approximately $2.5 million assuming 20 hours for each converter and compressor.	New materials of construction are needed to allow large and thick steel cylinders to be processed in large shredders.	A thorough inquiry of commercial vendors specializing in shredding and sorting must be conducted. Cost of a demonstration to develop this system is estimated at $10-15 million.
Conventional	Use of Existing Fixtures and Tooling. DISM-56-OG	**Accepted** Technology exists in each of the diffusion plants that permits the removal of major components without new equipment. The methods and equipment have been proven and have been in use and improved upon from time to time for over 40 years. This is an accepted technology.	An integration of advanced cutting techniques.	All jigs and fixtures would have to be located and if necessary, retrofitted to restore them to working condition. Existing jig and fixture fabrication drawings would need to be recalled from archives where necessary.

Technology Lo

Dismantle

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

Enrichment Process Buildings

Process Support Buildings

Cooling Towers

Pumping Stations

Laboratory Facilities

Special Development Facilities

Administrative Facilities

Electrical and Electrical Switch Gear

Problem Area/Constituents	Reference Requirements	Subelements	
E.Disassembly of Major Components (cont.)	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Dismantlement	Conve (cont.)
Electrical Equipment (PCB Contaminated)	TSCA FFCA • Complete disposition of PCB electrical equipment. 9/94		
Ventilation System (PCB Contamination)	TSCA FFCA • Complete PCB Ventilation gasket removal from K-29, K-31, K-33, 8/2001 • Complete dispoal of PCB waste. 12/2015		
F. Enabling Technologies	Refer to Volume1, Chapter 6, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.		Confi Verific

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Conventional (cont.)	Advanced Automatic Fixtures, Bug-O, etc. DISM-67-OG	**Accepted** The cascade improvement program completed in the early 1980's for the diffusion facilities used automated positioning tooling for cutting and welding to modify steel components including converter shells. This same tool concept can be adapted to cutting in the cascade assuming the appropriate delivery system. The technology is a certainty to work for cutting round piping such as diffusion cascade piping. Careful attention will need to be paid to shrouding the area where the cut is taking place to avoid spread of airborne contamination. This would translate to a savings of up to $20 million for one major facility alone.	Development needs - None. Improvement needs - A significant demonstration of a prototype will be required in the actual environment of the diffusion cascade. The demonstration would need to define the best way to power and control the tooling in a remote operating mode. Integration with a robotic delivery platform would significantly compound the total benefit. Savings of 5-10 times those sated under "Status" could be realized.	Roughly a man year of design would be required to design a prototype. The total hardware cost would be approximately $100K in 1992 dollars. No significant software is required although interlocking with any robotics would be necessary and may require approximately 0.5 man years to design. No facilities are needed over those existing in Oak Ridge. The tooling would be duplicated from the prototype. Approximately 20 different sizes would be required resulting in a total procurement cost of $500K for the three larger facilities. Assumes each cost $25,000.
	Saws DISM-68-OG	**Accepted** Technology exists in each of the diffusion plants that permits the removal of barrier from converter assembled bundles without new equipment. The methods and equipment have been proven and have been in use (and improved upon from time to time) for over 40 years.	Investigation of best available cutting media. The equipment that was used at the K-25 site and is used at the Paducah and Portsmouth sites to disassemble gaseous diffusion converters would require removal from storage.	All equipment would have to be located and if necessary retrofitted to restore it to working condition. Existing equipment drawings would need tobe recalled from archives where necessary. **Cost:** $100K Engineering to locate and supply new improved engineering tool designs. $400K to repair and build new tooling. Approximate total cost estimate: $500K.
	Use of Existing Equipment for Disassembly of Centrifuge Machines. The decontamination requirements for centrifuge clean-up are not unusual to other equipment decontamination. However, certain components require special equipment and employ special techniques that allow them to be cleaned and stored in a more effective manner. DISM-69-OG	**Accepted** The equipment has been consolidated in K-1420 and installation and check-out completed. There are people on-site that have expertise in both machine disassembly and decontamination techniques using the specific equipment. Specific technical information is available but may be classified. Disadvantages: Exact disposition of the hardware and materials after D&D was never determined. The equipment has been setting several years any may require maintenance prior to being usable.	Requires disposal of effluent and classified/contaminated hardware that meets the requirements of today's environmental standards.	Requires completion of the procedures and documentation necessary to start the facility. Equipment would require full check-out and operational testing.
Configuration Verification	Computer Based D&D Information Retrieval System: Fiber optic high speed networks with corresponding servers. DISM-70-OG	**Demonstration** Status exists with FDDI networks being the primary nominee for this purpose. An FDDI network exists within Energy Systems and is being evaluated through the mathematics and physics group and C&TD. The application of this technology initially only requires customizing to meet the exact distribution requirements of the D&D program.	Specific programs, technology development needs, and technology improvement needs.	Cost of proof of principle, amount of resources, equipment, hardware, software, facility, and educational needs. Reference requirements that are needed to deploy the technology successfully.

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EM Goals
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship

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EM Problem
Decommissioning (D&D)
Soils, Groundwater and Surface Water (RA)
Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
Enrichment Process Buildings Process Support Buildings Cooling Towers Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Electrical and Electrical Switch Gear	F. Enabling Technologies (cont.)	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Dismantlement	Configu Verifica (cont.)

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Configuration Verification (cont.)	As-Built Master Plan Data Base. DISM-71-OG	**Demonstration** This technology has been demonstrated at other sites on a smaller scale. Currently in Oak Ridge collection of as-built data is project determined and satisfies a limited area of the plant when existing. Efficacy with D&D activities is high. Tooling (drawings of) applicable to a specific task could be stored with the data for that task. The repetitive nature of the diffusion facilities make this technology even more attractive. Cost benefits are related to the degree that robotics and automation are applied to dismantlement.Simulations using the complete database visualized could allow problem definition prior to removal of contaminated equipment. Savings of 20,000 manhours could be realized during the start-up phase (3 yrs) of a major dismantlement design effort. In 1992 dollars this would be $1.6 million.	Intelligent systems capable of data translation and integration to common formats to interface with the As-Built Master Database. These developments should reflect in productions or transmission of data throughout the system and to other databases. A method to take electronic photographs and have a computer system convert these photos into 3-D dimensional engineering information is needed. (Pre-demonstration level). Holographic imaging may be a related development need. (Pre-Demonstration).	Capability to communicate efficiently with personnel outside of engineering/ at random locations throughout the plant areas. These individuals would communicate "red line change" to the database across the network. The computerized system would then generate new graphic features or site attributes and accurately enter them into the system.
	GIF Images to Enhance As-built Documentation. The specific technology exists in the image analysis and desktop publishing disciplines. The technology needs to be integrated into the design and as-built database requirements for its benefits to be realized. DISM-72-OG	**Pre-demonstration** Technology status is in the pre-demonstration to demonstration stage of development. The concept is to take electronic images from digital cameras and camcorders as well as scanned images of common photographs and enter them into the computer. These images will be converted to GIF format for storage and viewing and utilize graphics programs for contrast enhancement to obtain scale measurements and allow design personnel to evolve designs around complicated assemblies without having to routinely travel back to the contaminated site for observation. The cost savings in accuracy and time will result in a large benefit.	There are some technology development needs that are required. Most of these stem from a systems integration set of requirements. The selection of the most advantageous suite of hardware and software that allow ease of use, high accuracy and definition, and the capability to select and view these images and display them in publications the needs that should be addressed in a prototype system prior to initiation of a program wide set of GIF image specifications.	These are vague at the present time. This technology is one of the fastest moving in the computer industry. Commercial products are literally being introduced every day In addition, I&C at X-10 is currently doing a large amount of image storage and compression techniques for the Bureau of Engraving and Printing and the FBI that yield 10 to 1 factor of file size reduction with no discernable degradation in image quality.

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Buildings Process Support Buildings Cooling Towers Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Electrical and Electrical Switch Gear	F. Enabling Technologies (cont.)	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Dismantlement	Configu Verifica (cont.)

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram

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Alternatives	Technologies	Status	Science /Technology Needs	Implementation Needs
Configuration Verification (cont.)	Technical Resources Data Base DISM-73-OG	**Accepted** A search found the follow resources to be most helpful: 1. RAPIC (Remedial Action Information Center) is a comprehensive source of technical information pertinent to DOE's Remedial Action Programs. 2. LION (Library Information On-line Network) is a mini-computer system that supports on-line catalog and circulation services for books, journals and reports for all of the MM ENERGY SYSTEMS technical libraries. 3. ERA (Energy Research Abstracts) are a series of volumes published monthly that lists all energy related publications and reports. 4. NTIS CD-ROM - Available at the X-10 Central Research library are two CD-ROM disks which list all the documents published by the National Technical Information Service. 5. OSTI (Office of Scientific and Technical Information) - Serves the DOE community by collecting, processing, and disseminating information resulting from DOE research as well as worldwide information on subjects of interest to DOE researchers. 6. X-10 Central Research Library - This facility can do searches on your behalf on any technical subject but they have a charge for connecting to the various databases and a charge per printout of title and abstracts. Contact Robert Conrad 574-2764 or Bill Myers 574-6744.	None	None
	Acoustical Scanning of Drums: Modal analysis by inputting different types of excitation energy (both vibration and acoustic) into the structure and monitoring the structure. DISM-74-OG	**Pre-demonstration** Drums, pipes runs, storage containers, process vessels, and other closed articles may have large amounts of material deposited in them over time. By measuring a force input and acceleration of the response, the mass of the item can be derived. If this is significantly different from the design mass from the as-built drawings then the discrepancy can be addressed. The frequency and magnitude of the response of the structure will also be altered due to contributions of the additional mass. This will allow the determination of the actual level of the mass and also give a clue to the type of the mass inside due to density and damping of the additional components.	The application to K-25 may require some technology improvement needs that will require some software customizing and optimization of excitation techniques to yield the best results in the least amount of testing and analysis time. The talent exists in-house to ultimately automate this type of testing and run it in a knowledge based environment that would communicate its results directly into the integrated database of the D&D Information Retrieval System.	Implementation needs would require 2-3 modal testing engineers to baseline existing equipment and run a proof of concept tests with various excitation techniques on specific test articles. Integration and application to remote methods testing would require designing remote testing fixtures required for specific equipment, procurement required testing and designing and programminf of instrumentation transducers, the knowledge based analysis routine for each type of equipment tested (i.e., pipes, converters, valves, etc.). There exists approximately $500K worth of applicable instrumentation equipment for this effort. It is anticipated that a production system would require an additional $300K worth of testing instrumentation for evaluation of various signal processing and data acquisition techniques. Several computers would also be required for the knowledge base effort and D&D Retrieval System Interface. Total approx. cost - $300K.

Technology Logi

Dismantlement

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternativ
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Enrichment Process Buildings Process Support Buildings Cooling Towers Pumping Stations Laboratory Facilities Special Development Facilities Administrative Facilities Electrical and Electrical Switch Gear	F. Enabling Technologies (cont.)	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Dismantlement	Configuration Definition

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram
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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Configuration Definition	Laser Triangulation Mapping: triangulation mapping with laser scanning of equipment in contaminated areas will establish an as-built database for the specific equipment immediately prior to D&D. This technology can confirm the true as-built status and allows decisions to be made real-time on the status of disassembly the specific equipment in question. Once D&D has been approved, this technology has established an exact relative set of dimensions for the robotic or remote manipulations necessary to achieve the task at hand. This gives coordinates for remote or robotic manipulation during the D&D and benifits on personnel doing D&D and running the potential to hazardous exposure as well as improving speed. The instruments should scan and measure the entire compressor/pump area in approximately 30 minutes and relate these data to the design and graphics database. DISM-75-OG	**Pre-demonstration** Laser scanning and distance mapping have been applied in many different disciplines. Actual integration into a computer 3-D database for remote manipulation is probably in the pre-development stages by commercial enterprises.	Specific detailed software that integrates the 3-D mapping to an existing database for use in robotic or remote manipulation applications will be required. Manipulation of the database and adjustment/calibration of the sensors in a real-time field mode of operation will be necessary to achieve success of this program.	1. A development effort between Energy Systems and commercial systems developers will be required. 2. A resource of programmers, workstation computers, lasers, I&C coordinators, commercial firms, and best efforts contracts will be required to demonstrate this technology. 3. After a 1-2 year development effort with individuals skilled in robotics, mechanical design, electronics design, software design, and optics and optical mapping/ a sufficient expertise should be available to initiate a design and procurement specification for procurement of multiple units to accomplish the optimum methods of D&D utilizing either/or remote or robotic methods.
	Qualitative IR Thermography to detect piping flaws, piping contents, or effect of invasive thermal techniques (e.g. laser, torch cutting). DISM-76-OG	**Demonstrated** Advantage: inexpensive, portable, noninvasive, passive measure, realtime or VCR/still imaging. Reasonable compact apparatus (roughly 75 lbs and 6 cu ft). Excellent, initial, gross detection method. Disadvantages: Image often requires trained interpretation. Emissivity differences and/or local spurious infrared sources may complicate image analysis.	Requires natural or applied transient or steady-state heating. Method works best with IR=flat background.	ATD's 2 AGA systems require liquid nitrogen and should not be used in a high shock or vibratory environment. Only a few hours of sampling time per battery charge, although AC power also available.
	Video Mapping - video (or photographic) imaging for configuration mapping, evaluation, and control. DISM-77-OG	**Demonstration** Video images can be an effective means of establishing configuration layouts for planning and executing work. Digitizing video (photographic) images for establishing baseline layouts and for computer-automated comparison of different positions with a baseline to characterize and establish equipment differences would facilitate planning and work direction. Comparison of multiple digitized images to highlight differences and conversion of images to line drawings is a well-established, demonstrated set of technologies.	Technology development needs include the assembly of an imaging/computer system, software development, procedure development, and personnel training.	Resource requirements and development needs are as follows: 1. Imaging, computer, and related hardware (approx. $40K-60K). 2. System integration and development (approx. $300K-400K). 3. Development personnel: image technologist, software specialist, project manager. 4. System functional testing. 5. 9 to 15 months development. Deployment Requirements: 1. Procedure development and documentation ($30K to 50K). 2. User training ($10K - 20K) 3. System replication cost (if more than one system) ($60K - 80K).

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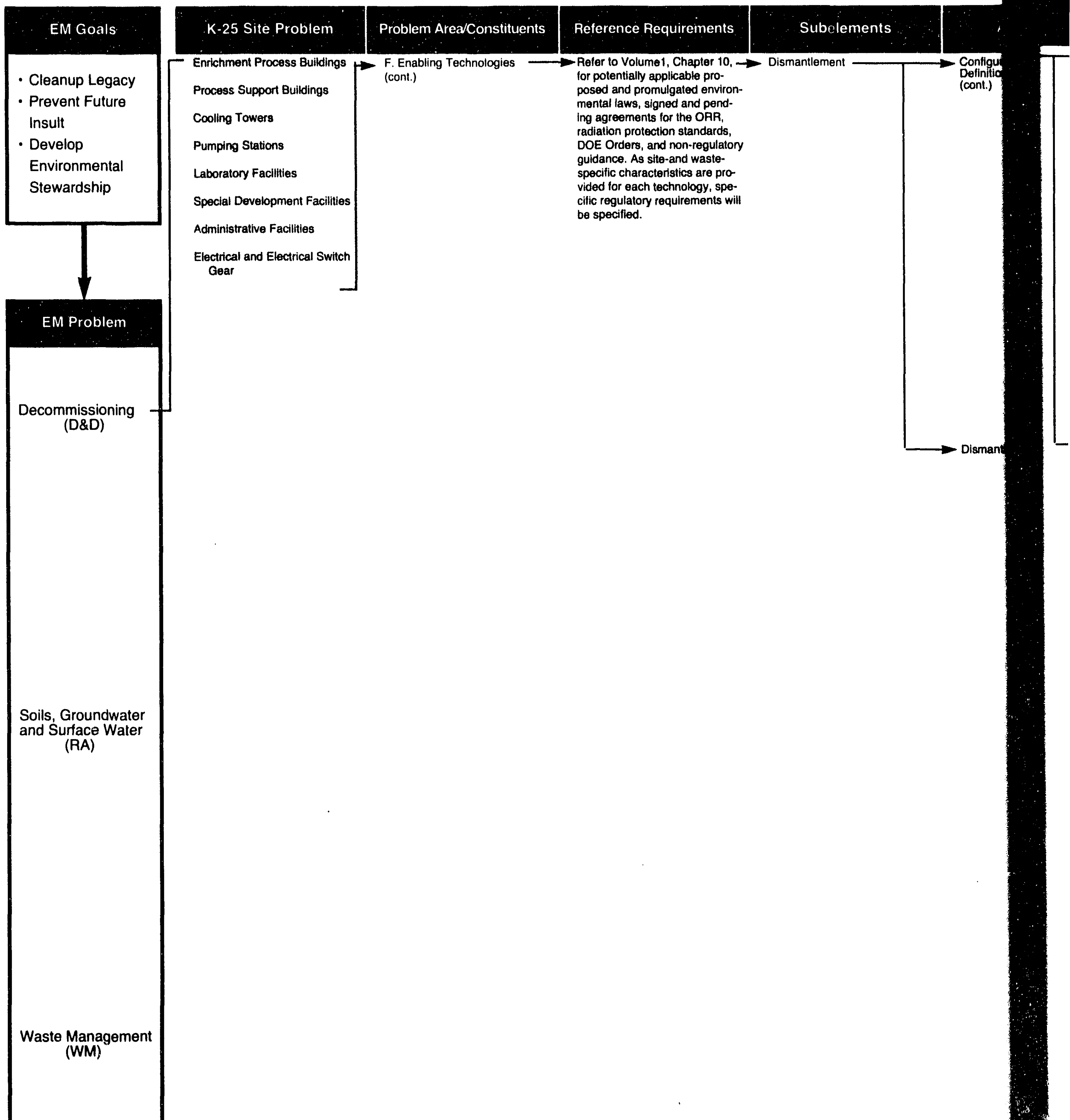

Logic Diagram

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Configuration Definition (cont.)	Photonic Removal of Contaminants - removal of contaminants by laser ablation, photolysis, etc. (in-situ removal of small quantities of surface contaminants). DISM-78-OG	**Pre-demonstration** Between Tech. Dev. & Improvement State - The technical approach to surface removal of materials and coatings by laser ablation, photo-induced thermal shock, photolysis, and other light-driven means is a well-demonstrated approach receiving greater current attention. It has the advantages of quickly removing materials at controlled rates and for which the depth of removal can be controlled. A specific technique from the area of photonics removal would facilitate the in-situ removal of small levels of contaminants, thus allowing the immediate disposition of dismantled equipment for disposal. Thus, cost savings from lower material handling, avoidance of more complex and costly decontamination processes, and avoidance of mixed waste generation should be achievable. Such cost savings should be in excess of $200 million.	The technology lies between the technology development and improvement state. It has been demonstrated and used outside of the laboratory but scale-up to major implementation has not been demonstrated. Complete development, including a viable prototype system, is estimated at approx. $1.0 million and requires approx. 12 to 18 months.	To implement a system would cost between $150K and $250K depending on desired removal rates. Additional requirements would be automation or semi-automation of the device for remote or limited man interface during operation.
Dismantlement Support	Point and Direct: A semi-automated approach to directing the cutting, disassembly, and removal of equipment or materials. Approach would use an operator with a light wand to identify work paths for optically guided tools. DISM-80-OG	**Evolving Technology** (conceptual) - Concept is in pre-proof of principle state but, relies on off-the-shelf components to implement. Thus minimal development will be needed. Should be a good compromise where full automation or robotics is not achievable or not practical.	Develop prototype and demonstrate. Requires integration of hardware and minimal software development. Cost to complete development is approximately $500K.	Prototype system should be field tested to evaluate and identify deployment needs. Testing could be done in conjunction with field demonstration of one of the dismantlement or decontamination technologies.
	Improved Protective Clothing and Equipment DISM-81-OG	**Evolving Technology** Due to the large amounts of protective clothing and equipment required to protect workers during the dismantlement of the massive diffusion plants a very large sum of money has been included in the base case estimate. This estimate includes both direct cost of the equipment and the indirect cost of lost worker efficiency due to the limitations of working in the currently available equipment. A total cost of over $1 Billion has been estimate4d. No known program currently exist to develop specific equipment of this nature for the diffusion plant dismantlement tasks.	Investigation of specific requirements for the dismantlement of a diffusion plant relative to criteria for this equipment must be generated. Human Engineering techniques must be used to model the doning dolfing routines and new techniques must be developed to speed this process as well as to specify newer materials more capable of recycle and or safe disposal. The cost of such a program may be in the $3-5 million range. Studies must be made to plan the dismantlement sequence to permit design of enclosures both mobile equipment cabs and portable containments that better suit the repetitive nature of the diffusion facilities to be dismantled. The cost of this program would be in the $2-3 million range.	Full engineering and development too the equipment is needed. Many commercial and/or opportunities exist to work outside the government sphere to engineer and develop such equipment. Most of the work would not involve high-tech but would require a dedicated team with ergonomic skills. Cost of such a task would be ion the $6-10 million. Payback potential relative to the $1 billion estimate within the diffusion plant tasks could save up to 50%.

Remedial ...

Remediation involves the removal of radioactive or toxic contaminants from ...
polymer grouting methods to retain the contaminants and prevent the spread o...
were categorized as physical or chemical. A number of chemical methods wer...

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ts from soils, burial grounds, and groundwater, or of "fixation" by cement or
read of them. Methods for removal of contaminants from soils and solids
ds were identified for removing contaminants from groundwater.

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternati
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Soils, Buried Waste	Uranium In Soils	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Treatment	Physical Separation
					Chemical Separation

EM Problem

- Decommissioning (D&D)
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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Separation	Solids Separation REMA-11	**Demonstration** The equipment has been tested in the mineral industry. Tests for removal of uranium are expected for the "Uranium in Soils Integrated Demonstration." Wastes: Rejected contaminated soil fractions (for further treatment). Costs: Probably moderate (< $100/ton); likely to be used to reduce the volume of soil requiring more expensive and aggressive chemical treatment.	Development and testing with K-25 soils. Soil characterization by particulate group (contamination and characteristics needed for reparation - density, wettability, size, etc.)	Normal. Plans for handling and treating the separated fractions. Establish a suitable treatment level. Development/demonstration costs could be from a few $M to perhaps $10M.
	Soil Washing REMA-12	**Demonstration** (for somewhat similar applications) Soil washing separates soil fractions by size (a subset of physical separations but can include some leaching). It is accepted in the mineral industries. Demonstration for Pu removal is in progress. Demonstration for uranium removal is planned. Waste: Contaminants recovered from the soils. Costs: Depend strongly on leach and subsequent treatment required, could be <$100/ton.	Demonstration that the uranium is largely in a few size fractions. Characterization and demonstration at K-25.	Normal. Establish a suitable treatment level. Select necessary subsequent treatment (leach, etc) steps or disposal options. Development/demonstration costs could be a few $M.
	Mobile Washing/Leaching Unit REMA-13	**Predemonstration** This is a particular way to apply soil washing and leaching. EPA has demonstrated a unit for other applications. Wastes: Leach liquors (for further treatment). Costs: To early to know, perhaps a few $100M/ton.	Characterization to determine soil fractions, uranium distribution, and uranium form. Demonstration with K-25 soils.	Normal. Establish treatment level. Select and develop additional treatment steps (leach, etc.) Development/demonstrarion costs could be a few a $M.
Chemical Separation	Acid Leaching REMA-14	**Predemonstration** (Accepted/demonstrated for ores). Bench scale tests for Fernald. Wastes: Leach solution (for further treatment, probably by ion exchange or solvent extraction using mineral or technologies). Costs: Uncertain, depends upon soil separation technology available. Need to avoid consuming too much acid-dissolving limestone. Costs could be high (>$100/ton).	Leach tests with K-25 soils and separated fractions of those soils.	Establish treatment level. Design uranium recovery systems. Development/demonstration costs could be a few $M, perhaps <$10M.

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Soils, Buried Waste	Uranium in Soils	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Treatment	Chen Sepa (cont.) Fixati

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

Chemical Separation (cont.)	Alkaline Leaching REMA-15	**Predemonstration** (Accepted/demonstrated for ores). Bench scale tests for Fernald; demonstration likely. Wastes: Leach residue and leach solution for recovery by solvent extraction. Cost: Too early to determine. Fernald tests may provide a meaningful basis. Perhaps a few hundred dollars per ton.	Application to soils is being tested (U in Soils I.D.). Tests and demonstrations on soils and separated soil fractions, especially on soils from K-25.	Establish treatment level. Demonstration needed with K-25 soils. Design solvent extraction recovery system. Development/demonstration costs could be a few $M, probably <$10M.
	Water Extractant REMA-1	**Demonstration** Several groups exploring the concept. Complete systems including uranium recovery have not been put together. Wastes: Recovered uranium concentrate. Costs: Too early to estimate. There is only a low probability that much uranium at K-25 will be soluble. Could be moderate (<$100/ton) only if no complications are found.	Study behavior of uranium in complex soil chemistry.	Numerous. Establish treatment levels. Development/demonstration costs could be <$10M.
	Electrokinetic Removal REMA-2	**Pre-Demonstration** Tests have been limited to relatively idealized conditions, usually small scale, often with sand or simple soils. Costs are very undertain at this time, not expected to be low. Waste volume depends upon method for removing metals at the electrodes, probably moderate.	Much needs to be known about metal specie in soils and electrokinetic transport. Determine need to oxidize uranium to improve mobility, effects of variable water content, and water flow. Develop a suitable uranium recovery system from region near electrodes. Establish maximum acceptable electrode spacing.Tests are needed on complex soils like those at K-25. Complete systems need to be tested, including removal of metals at the electrodes.	Numerous. Establish treatment level. Establish system for removing uranium from electrode regions. Development/demonstration costs will probably be moderate ($1M to $10M).
Fixation	In Situ Cement Grouting REMA-16	**Accepted** Wastes: All soil and additives not returned to the ground. Costs: Reported to be <$100/ton) Affects future use of soils.	Treatability studies for specific soils. Some question of very long-term stability.	Normal
	In Situ Polymer Grouting REMA-17	**Limited in-field** tests/demonstration. Moderately high costs expected, increased soil volume, long term stability questioned. Affects future use of soil.	Treatability tests. Possible demonstrations.	Normal Development/demonstration costs could be low, perhaps <$1M.
	In Situ Vitrification REMA-18	**Demonstration** (without uranium) Wastes: Not applicable. Cost: High (perhaps very high) >$100/ton. Affects future use of soils.	Tests with K-25 soils and uranium. Demonstration of connecting multiple treatment regions. Assessment of long-term stability and leachability.	Assess presence of metals, tanks, etc., that could inhibit vitrification. Development/demonstration costs may be moderate (a few $<M).

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- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

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K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alter
Contaminated Soils, Buried Waste	Uranium in Soils	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Treatment	Fixation
	Tc in Soils	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Treatment	Fixation
				Chemical Separation

Logic Diagram
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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Fixation	Ex Situ Vitrification REMA-19	**Conceptual** Wastes: Vitrified soils and additives Costs: Expected to be excessive.	Develop suitable mixtures and methods. Assess stability and leachability.	Normal Development/demonstration are likely to be several $1M.
Fixation	In Situ Grouting REMA-81	**Pre-demonstration** (conceptual). Tc hasn't bee addressed specificly during in situ tests. Costs are likely to be moderately high. Waste volume will be moderate if the grout can be left in situ, only some of the expansion volume would have to be treated as separate waste.	More specific studies with Tc are needed, and effective retention may be difficult. Addition of Tc adsorbents could be considered.	Normal Development/demonstration costs are likely to total several $M.
	In Situ Vitrification REMA-82	**Demonstrated** For selected cases. Volatility of Tc is in question. Costs are expected to be high. Probably applicable only for the most serious problems. Waste volume whould be small, only concerned with off-gas treatment wastes.	Very limited number of tests available. Specific tests needed for K-25 soils and contamination (form of Tc). Volatilization of Tc must be assessed.	Normal Development/demonstratioon costs could total several $M.
	Ex Situ Grouting REMA-83	**Pre-Demonstration** Large scale grouting has been performed with sludges containing low concentrations of Tc, but Tc was only one of the target contaminants. Retention wasincreeased by grouting, and one additive has been reported to improve retention. Costs are not reported, but are expected to be at least moderately high. Waste volumes would be large, but will consist largely of grouted soil which passes leach tests.	More attention needs to be devoted to Tc behavior, additives which increase retention, and understanding the Tc specie in grout and mechanism for Tc retention.	Normal Development/demonstration could be only a few $M.
Chemical Separation	Soil Washing/Leaching REMA-84	**Pre-Demonstration** Demonstrated on somewhat similar problems, apparently not with Tc. Need to show that suitable removal can be achieved and conditions affecting Tc removal. Cost for leaching other materials reported to be $45 to $100/ton. Waste volume could be small if effective concentration system is developed.	Evaluation of washing enefits for K-25 soils. Extractant and ligands for Tc. Recovery and concentration methods.	Normal. Establish treatment level. Development/demonstration costs could be several $M.

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	→ Contaminated Soils, Buried Waste	→ Heavy Metals in Soils (Hg, Cr)	→ Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	→ Treatment	→ Fixation

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- Decommissioning (D&D)
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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Fixation	In Situ Vitrification REMA-71	**Demonstration** Bench scale tests and a few large scale tests have been made aimed at vitrification of radioactive materials, but toxic metals and K-25 soils were not studied intensively. Costs have not been estimated, but probably will be high. Waste volume will depend only upon the off-gas treatment required. Volume of soil will actually decrease.	Tests to look at specific toxic metal retention and K-25 soil compositions are needed. Mercury contaminated soils will be a particular problem.	Implementation will require assured understanding of the behavior of all contaminants in the soil during ISV. Development/demonstration costs could be high (>$10M).
	In Situ Cement Grouting REMA-72	**Accepted** Demonstrated. Offered commercially. Moderate costs reported ($30 to $70/ton). Waste volume equilivent to expansion of soil, approximately the amount of additive used.	Assessment of long term results. Reduction in final waste volume.	Normal
	In Situ Reduction and Fixation REMA-78	**Predemonstration** A concept that may work with some metals. Costs are likely to be low, perhaps in the range of $100/ton. The principal question is the effectiveness, long-term stability, and regulatory acceptance. Waste volume would be minimal.	The effectiveness of this technology needs to be demonstrated on a long-term basis for several toxic metals of interest at K-25. The rate of reoxidation needs to be established.	The regulatory acceptability needs to be determined. Development costs to demonstrate long-term stability could be several $M.
	In Situ Polymer Grouting REMA-75	**Demonstration** (Polymer has been demonstrated for other applications). Costs not given, but likely to be high, depends upon maximum soil loading in polymer. Waste product will be largely the treated soil.	Tests with K-25 soils and for long term stability.	Normal Development costs could be a few $M.
	Ex Situ Vitrification REMA-76	**Demonstration** Being developed for high level wastes. Costs likely to be very high. Waste product volume, high but not likely to leach.	Both laboratory and engineering work with K-25 soils. Select additives, if needed. Evaluation of retention.	Normal Development/demonstration costs will be high (several $M).
	Ex Situ Sulfur Polymer Grouting REMA-77	**Pre-demonstration** Contaminant retention and long-term stability should be good, but this hasn't been shown. Material costs may be moderate to high. Wasteproduct volumes will be high but produces little or no secondary waste for additional treatment.	Development work with K-25 soils. Basic research to optimize grout performance.	Large scale testing needed. Development/demonstration cost could be only a few $M.

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- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

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Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternat
Contaminated Soils, Buried Waste	Heavy Metals in Soils (Hg, Cr)	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Treatment	Chemical Separation
	Chlorinated Volatile Organic Compounds (VOCs) in Soils	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Treatment	Physical Separation

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Separation	Electrokinetic Removal REMA-73	**Pre-Demonstration** Tests have been limited to relatively idealized conditions, usually small scale, often with sand or simple soils. Need to establish the removal levels and removal rates that can be achieved. Costs are very uncertain at this time, not expected to be low. Waste volume depends upon method for removing metals at the electrodes, probably moderate.	Much needs to be known about metal specie in soils and electrokinetic transport. Tests are need on complex soils like those at K-25. Complete systems need to be tested, including removal of metals at the electrodes.	Normal. Establish treatment level. Development/demonstration costs could be several $M.
	Ex Situ Soil Washing/Leaching REMA-74	**Pre-demonstration** Limited work at present. Level of removal needs to be established for K-25 soils. Costs will be high. Waste volume is unknown, depends upon both leach performance and metal recovery method. Acid leaches will not be practical with high limestone present.	Better understanding of chemical form of metals in soil, better leach liquors, and metal recovery/concentration methods.	Normal. Establish treatment level. Development/demonstratrion costs are likely to be several $M.
Physical Separation	In Situ Vacuum Extraction (Soil Venting) REMA-31	**Accepted/Demonstrated** Technology has been demonstrated and applied to porous soils. Generally applicable only above the water table. Waste will be filtered and recovered VOCs on carbon beds (or other material) used to remove VOCs from extracted vapors. Operating costs: Generally low for soil treatment (probably <$100/ton), depends on contaminant and level of contamination.	Development Characterize K-25 soils for permeability and VOC retention. Treatability studies and demonstration with K-25 soils.	Normal implementation needs. Suitable wells. Mobile vapor recovery equipment to move to different sites as needed.
	In Situ Steam Extraction REMA-32	**Accepted/Demonstrated** Has been used in EPA demonstrations and commercial operations. Most useful when higher temperatures are needed to remove VOCs absorbed in soil; may be helpful for some of the less volatile VOCs. Probably best above the water table, but not exclusively. Waste will be filtered and extracted VOCs on adsorbent (carbon). Maximum recycle of condensed water needed to minimize waste generation. Costs: Probably moderate for soil treatment (depends upon soil and contaminant; perhaps between $50 and $150/ton)	Development Determine equilibrium for K-25 soils over moderate temperature range. Treatability studies and demonstration with K-25 soils.	Normal implementation needs. Both injection and extraction wells needed.

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Soils, Buried Waste	Chlorinated VolatileOrganic Compounds (VOCs) in Soils	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Treatment	Physic Separa (cont.) Destru

EM Problem

- Decommissioning (D&D)
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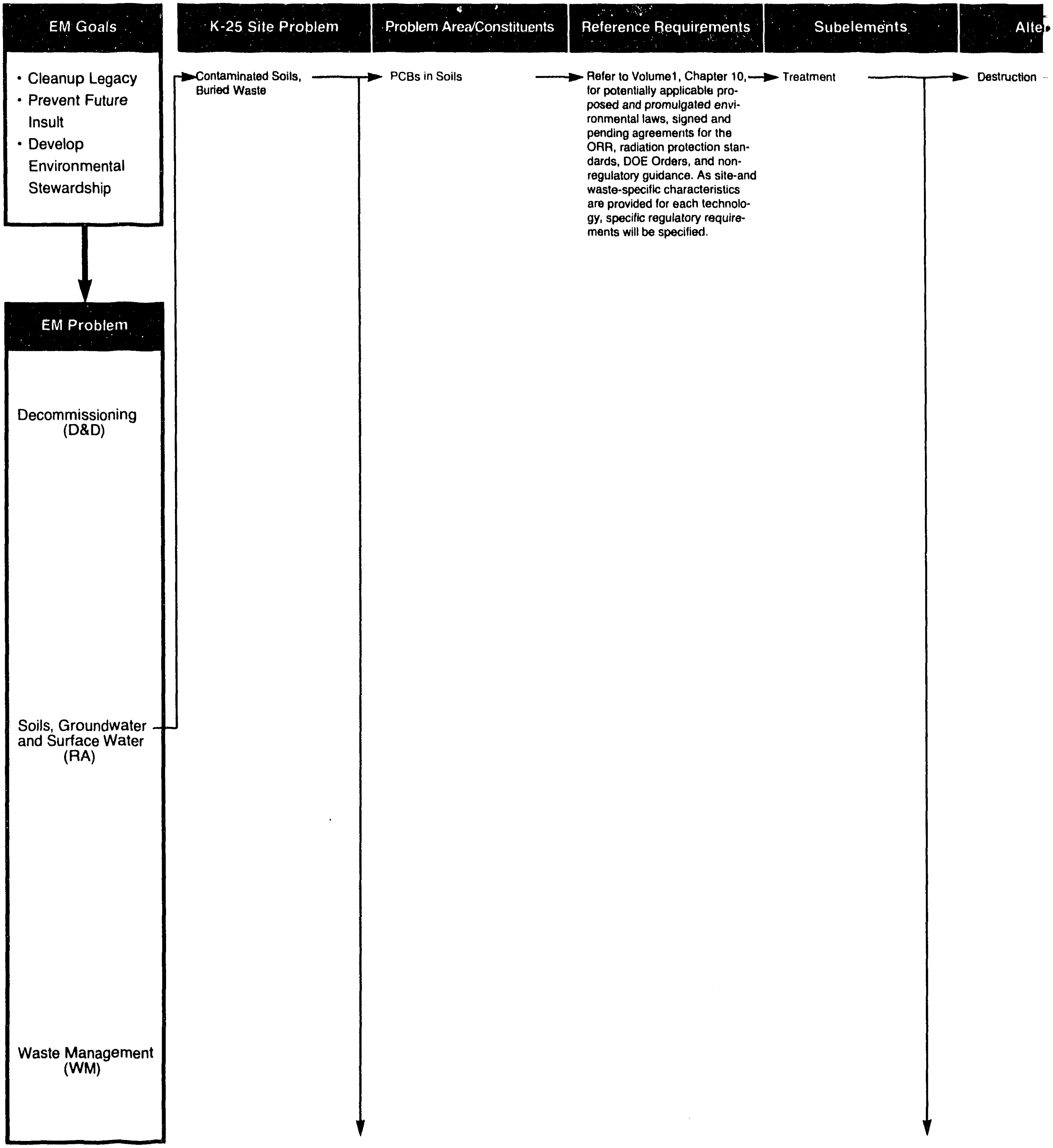
Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Separation (cont.)	Vapor Extraction with RF Heating REMA-33	**Pre-demonstration** Improves vapor extraction with added heat. Requires grid of drilled holes for transmitters. Pilot test completed at one site. Hardware is commercial. Waste: Principally from adsorption beds to recover VOCs from off-gas. Costs are conjectural at this time, but could be low (<$100/ton). Wastes will be from the off-gas treatment system.	Development Tests and experience needed with a variety of soils and conditions, especially conditions at K-25.	More development. Treatment levels need to be established. Development/demonstration costs could be several $M.
	Ground Freezing REMA-34	**Conceptual** Idea has been evaluated by theories and models. Limited experimental tests. Wastes: This concept only holds VOCs for further treatment; wastes depend upon subsequent treatment. Wastes would be associated with the subsequent treatment system. Costs are only conjectural at this time, and probable depend u the time the soil needs to be frozen. Probabl;· <$100 per ton.	More experimental tests under appropriate conditions for K-25. Development of complete process systems for treating soil after freezing.	Total (complete) treatment concept. Development/demonstration costs may be a few $M.
Destruction	In Situ Biodegradation REMA-35	**Pre-demonstration** (for some VOCs and conditions). Degradation of most petroleum-based hydrocarbons is accepted technology. Degradation of chlorinated compounds and other more refractory compounds is under development. Wastes-Minimal. Costs: Usually low (<$100/ton), but depends upon the problem.	Science and development. Study of new organisms (natural and altered); study of effects of soil conditions; and study of degradation of refractory compounds, especially chlorinated compounds. Better methods for getting oxygen and nutrients to contaminated regions. Tests with K-25 conditions.	Normal, conditions of soils and contaminants must be well characterized. Treatment goals must be known. Development/demonstration costs for better and more reliable removal could be a few $M (<$5M).
	Ex Situ Biodegradation REMA-37	**Demonstrated** (for some contaminants and soil conditions). Severai ɩactor designs have been tested. Waste: Probably only limited biosludge, if the treated soil can be returned to the ground (contains no other toxic materials).	Science and development. Study new organisms (natural and altered); reactor conditions; and degradation of more refractory compounds, especially chlorinated compounds. Reaction rates are critical to holding down size and costs of reactor.	Normal. Treatment goals must be known. Organism and methods for specific VOCs must be available. Costs: Moderate, one estimate was $165/ton. Development costs could be a few $M.
	Microbal Degradation with Methane REMA-38	**Pre-demonstration** In laboratory test, tetrichloroethane was the only compound not degraded. Potential for use in situ as well as ex situ. Waste volumes should be minimal. Costs could be low (<$100/ton).	Results need to be confirmed and tested with a variety of soils and conditions and extended to high removals. The technology does not appear ready for large scale testing.	Technology is not ready for reliable cost estimates. Development/demonstration costs could be several $M.
	Corona Discharge REMA-39	**Evolving Conceptual.** Unknown efficacy. Wastes: unknown compounds Costs: est. $100/ton.	Identify destruction mechanism. Verify degradation of VOCs.	Not ready yet.

Technology Logi

Remedial Act



Logic Diagram
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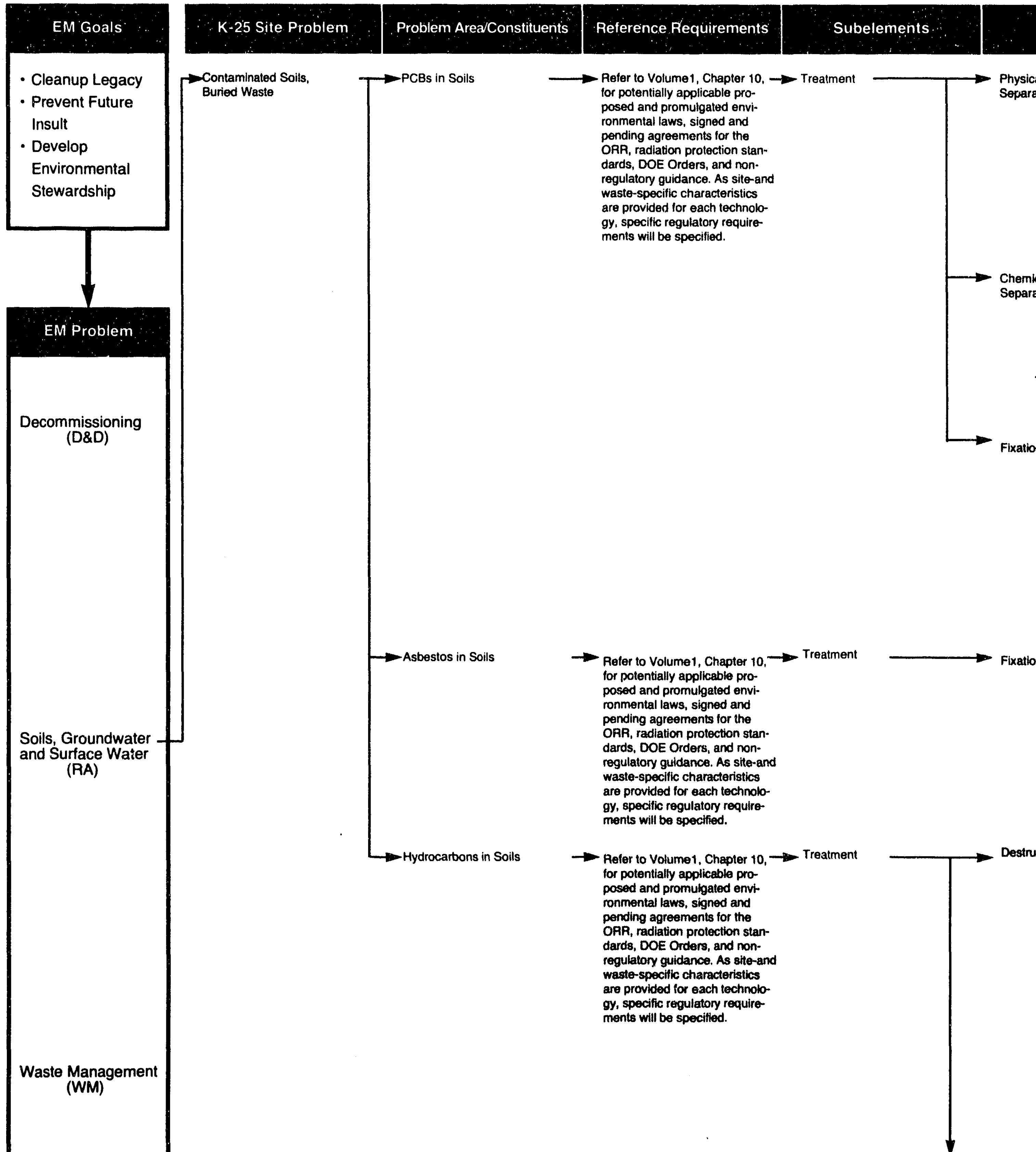
Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Destruction	Incineration REMA-51	**Demonstrated.** Very high PCB soil was incinerated with 99.9999% destruction, detectable PCBs remained. Incinerator temperature and residence time requirements are specified. Cost reported to be between \$100 and \$800/ton. Treated soil not useful; may still contain toxic metals and radioactivity.	Treatability tests with K-25 soils. Test benefits of removing soil fractions. Reliability of operations must be established.	Treatment levels need to be established. Removal efficiencies reported must be acceptable. Any further demonstration needed could cost several \$M.
	Bioremediation REMA-52	**Pre-demonstration.** Degradation observed in Hudson River sediments. Current studies in laboratories. Ability to meet required treatment levels is not established. Costs could be low. In situ operations would leave little waste.	Promising technique needs understanding of organisms and effects of operating parameters.	Treatment levels need to be determined. Development/demonstration costs could be several \$M.
	Alkali Metal Polyethylene Glycolate (APEG) REMA-53	**Demonstrated /Accepted** Developed with extensive EPA participation. Reduction of 75% to 99%. Cost reported to be \$200 to \$500/ton. Waste volume will be mostly the treated soil with alkali content increased. Development costs have been funded largely be the GPA.	Treatability tests needed for K-25 soils. Optimization needed to insure destruction performance near the top of the range observed in demonstrations. Improve removal and reliablitity of removal.	Treatment level needs to be established.
	Photocatalytic Oxidation REMA-55	**Demonstrated** for groundwater, **Conceptual** for soils. Current tests of UV lights at LLNL and elsewhere. Solar tests at LLNL. Test include other chlorinated compounds. Opacity of soil suspension and retention of TiO2 catalyst are problems. Waste volume should be low. Costs are speculative, but could be <\$100/ton.	Operating system needed that can handle opacate solids. Applications to K-25 type soils needed.	Too speculative to estimate costs. Development/demonstration costs could be a few \$M.
	In Situ Vitrification REMA-59	**Predomonstration** Test appear to have destroyed 99.9% of PCBs. Exact destruction levels probably were difficult to determine. Cost will be high. Waste volume could be small, depends upon off-gas treatment. Can handle several problems. Development costs could be several \$M.	Further testing of fate of PCBs and parameters affecting destruction.	Normal

Technology Lo
Remedial A



Logic Diagram
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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Separation	Low Temperature Thermal REMA-56	**Pre-demonstration** Limited tests with semi-volatile organic compounds. Costs not estimated, probably high (hundreds of dollars per ton). Waste volume, low to moderate, depends upon classification of residue and off gas treatment.	Fate of PCBs needs to be established. Ability to handle high concentrations of PCBs should be tested.	Normal Further development/demonstration costs may rquire only low costs, perhaps <$1M.
Chemical Separation	Solvent Extraction REMA-57	**Demonstrated** (at Y-12 and elsewhere). Kerosene solvent; PCBs concentrated by distillation. Costs reported to be half that for incineration. Waste will be the cleaned soil and solvent discard.	Optimization for K-25 soils and conditions. Complete PCB handling cycle (including destruction or disposal) should be evaluated. The degree of removal with K-25 soils needs to be established and compared with requirements.	Treatment goals are needed. Solvent recycle and eventual disposal needs to be established. Further development/demonstration costs could be a few $M.
Fixation	Cement Grouting REMA-58	**Demonstrated** Questions remain on long-term stability. Good PCB retention; water loss suggested limited lifetime. Costs reported from one study to be approximately $200/ton. Waste volume will be high, soil volume plus additive volume, but should not be leachable.	Test PCB leaching to lower detection limits. Explore effect of other oils in soil and additives used.	Normal Furhter development costs should be small (perhaps <$1M).
Fixation	Asbestos Fixation	**Accepted** Current handling and containment methods appear to be adequate. Worker protection should be similar to that used in other asbestos removal operations Cost and waste volume are likely to be moderate.	Better and quicker methods for detecting the presence of asbestos in soils and buried equipment could reduce exposure.	Establish the needs and requirements for containment.
Destruction	In situ Biodegradation REMA-61	**Accepted** (for lighter hydrocarbons) Often combined with soil venting and called bioventing. Cost will be low, perhaps <$100/ton. Waste volume will be minimal.	Better methods for delivering oxygen and nutrients. Better understanding of soil structure.	Normal. Treatment goals needed.
	Ex Situ Bioremediation REMA-64	**Demonstrated** Much industrial interest. Costs are likely to be moderate, but will vary with contamination. Waste volume will be low if the soil can be returned to the ground.	Organisms and reactors that are more effective for the more refractive hydrocarbons, usually the higher molecular weight aromatic compounds.	Normal Further development/demonstration costs may be no more than a few $M.

Technology Log

Remedial A

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Soils, Buried Waste	Hydrocarbons in Soils	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Treatment	Destructi (cont.) Physical Separati Chemic Separat Fixation
		Uranium in Groundwater	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Treatment	Chemic Separat

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Destruction (cont.)	Land Farming Bioremediation REMA-70	**Accepted** Practice for several years. Has generated problems. Metal and radioactive contamination may prohibit use. Costs are low, perhaps several dollars/ton. Waste volume is low if accumulation of toxics is avoided.	Better ability to handle refractive organic compounds; avoid buildup of chlorinated compounds and other refractive materials.	Treatment levels needed. Accumulation of toxic metals and radioactivity may prohibit or restrict use. Establish the regualroy accerptability of land farming for these soils.
	Chemical Oxidation REMA-67	**Predemonstration** Laboratory tests were effective. Too early to assess costs, but are expected to be relatively high (perhaps a few $100 per ton). Waste volume determined by reagents required.	Only limited laboratory tests completed. Refractive compounds were noted. Need to assess effects on more refractive compounds.	Normal Development/demonstration cost may be a few $M or less.
	Oxidation in Cement Kiln REMA-69	**Accepted** Costs should be low and waste volume minimal. Capacity of kiln for solids will be low. Potential radioactivity may prohibit use for K-25 soils.	Commercial technology for liquids. Soils handling should be established.	Normal. Potential presence of radioactivity could prevent use with K-25 soils.
Physical Separation	Low Temperature Thermal Treatment REMA-65	**Accepted** Used on soils around underground tanks. Cost reported to be $74 to $184 per ton. Wastes will be treated soil (hpoefully clean) and off-gas equipment.	No urgent needs. Better characterization for low volatility compounds and relevant soils properties.	Normal
	Soil Venting/Vapor Extraction REMA-68	**Accepted** Common practice for light fuel spills. Costs are low (a few dollars/ton). Waste are minimal. Technology is usually recommended when air flow to contaminated region can be insured.	Better understanding of underground air flow and regions of contamination.	Normal
Chemical Separation	Solvent Extraction REMA-133	**Demonstration** Product might be treated soil with wasted loaded extractant.	Evaluation to determine correct solvent.	Normal
Fixation	Incorporation with Asphalt REMA-63	**Accepted** Costs are low ($50 to $100/ton). Additional waste should be minimal. Potential for radioactivity may limit use for K-25 soils.	Little technical need. Application limited by rate of asphalt production.	Normal
Chemical Separation	Coagulation/Filtration REMA-21	**Pre-demonstration** Technology is commonly used for water treatment; uranium behavior is the question. May not be chosen for uranium removal, but could be important if used for other purposes. Treatment cost are low, like conventional water treatment. Waste volumes are likely to be large and add significantly to cost.	Uranium behavior needs to be assessed for most probable operating conditions (ph, additives, etc.). Minimization of filtrate is needed. Actual removal efficiencies need to be established for K-25 waters.	May be needed for other purposes. Concentrations of other contaminates in the waste should be determined. Waste handling procedures should be established. Development/demonstration costs could be several $M.

Technology Lo

Remedial A

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Groundwater, Surface Water	Uranium in Groundwater	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Treatment	Chemic Separa (cont.)

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

Logic Diagram
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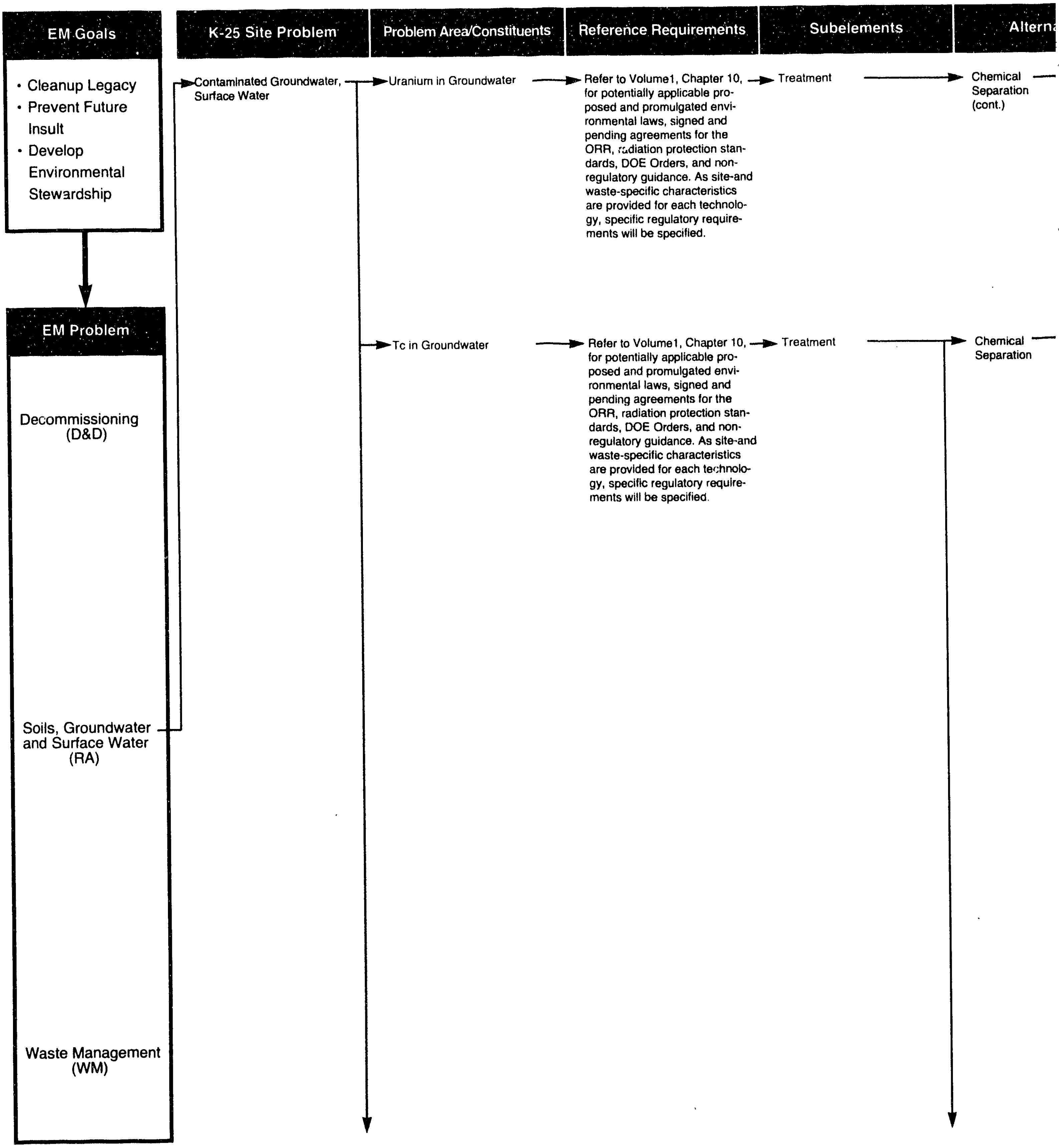
Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Separation (cont.)	Ion Exchange Treatment REMA-22	**Demonstrated** Systems used to treat water supplies have removed uranium effectively. Common practice in the mining industry, but usually with high concentration of ligand. Cost could be low to moderate; estimated at $6.70/1 000 gallons, but could be several fold higher. Regeneration and waste volume could affect total cost. Waste generation could be low if a good regeneration method is found.	Evaluate resins for selectivity, rate parameters, and optimal operating conditions. Test with full list of compounds in K-25 waters without adding ligands.	Normal Development/demonstration costs could be a few $M.
	Biosorption REMA-23	**Pre-demonstration** Laboratory test indicate high selectivities for uranium may be possible. Cost could be low if an efficient but low cost (less than a few dollars per 1000 gal.) adsorpent is found. Waste volume will depend upon the maximum uranium loading that can be achieved, probably will be moderate.	Incorporation of organisms or biological material into stable forms for use in efficient columns. Assess rate parameters and operating conditions. Low cost adsorbent production. Maximum uranium loading at relevant solution conditions. Larger scale testing.	Normal Development/demonstration costs should be a few $M, or less.
	Adsorption wtih Titanium Oxide REMA-24	**Pre-demonstration** Technology not ready for estimates. Waste volume could be high if regeneration is not possible. Both cost and waste volume depend upon loading capacity. Costs could be $10 per 1,000 gal.	Assessment of the uranium specie used in the test and the specie in K-25 waters. Selectivity for uranium. Regeneration technique, if possible. Maximum loading under K-25 conditions.	Need better information on performance with K-25 waters. Method for regenerationor disposal of spent beds. Development/demonstration costs could be a few $M.
	Adsorption with Granular Activated Carbon REMA-25	**Pre-demonstration** Successful removal in small scale operations, testing and treatment of drinking water. Did reach low conentraitons in limited tests. Information is insufficient to predict cost, but cost will probably be moderate if the solids waste generation problem can be handled. Otherwise, the cost will be high. Waste volumes will be high if the carbon cannot be regenerated. (Waste volume depends on the maximum adsorption capacity with K-25 waters.)	Evaluation of maximum capacity for uranium from K-25 waters, selectivity for uranium, effects of other water components, and possibility for regenerating or concentrating the uranium.	Normal Development/demonstraiton costs could be a few $M.

Technology Logi

Remedial Acti



Logic Diagram
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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Separation (cont.)	Reverse Osmosis REMA-26	**Demonstrated** Concentrates the uranium in a solution, not a solid. Concentrate will have to be treated further. Usually removes most dissolved materials, not specific for uranium. Cost for reverse osmosis unit alone should be moderated (perhaps a few dollars per 1000 gallons), but treatment of concentrate may raise the total costs.	Check the effects of other components in K-25 waters. Optimize treatment of concentrate and minimize eventual waste volume.	Can be constructed in relatively compact field units and may be most helpful for treating small flows. Futher development/demonstration costs should be low (possibly testing new membranes or K-25 waters) perhaps <$1M.
Chemical Separation	Reduction Adsorption REMA-121	**Predemonstration** Laboratory tests look interesting. Data are too preliminary to develop costs. Waste volume could be large if regeneration is not possible. Capital and operating cost could be low (a few dollars per 1,000 gal). Waste handling costs (spentbeds) could be moderates.	Better understanding of mechanism and important parameters. Insurance that Tc will not "bleed" from colums at long times.	Normal Development/demonstration costs could be a few $M.
	Ion Exchange REMA-122	**Demonstration** Tests made on water with numerous contaminants (including Tc). Can reach sufficiently low concentrations. Cost information not supplied, probably high unless low-cost ion exchange materials are used. Waste volume could be low if good regeneration system is available.	Only bench scale tests, and only few proprietary materials tested. Column design and regeneration methods needed. Seek high resin capacities and selectivities.	Normal Development/demonstration costs could be as low as $1M.
	Reverse Osmosis REMA-123	**Predemonstration** Reverse osmosis has been accepted for removal of many contaminants from water, but it has not been demonstrated with Tc. Since RO is general not selective, it would be expected to work with Tc. Costs could be moderate, perhaps a few dollars per 1000 gal depending upon the concentration of other soluble materials and treatment of the concentrate. Waste volumes are likely to be moderate; from treatment of the concentrated "reject" stream.	Rejection of Tc by commercial organic and inorganic RO membranes needs to be established. Treatment for concentrate should be determined.	Normal Cost for further development could be a few $M.

Technology Lo

Remedial A

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Groundwater, Surface Water	Tc in Groundwater	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Treatment	Chemic Separat (cont.)
		Heavy Metals in Groundwater (Hg, Cr)	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Treatment	Chemic Separat

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram
ial Action

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Separation (cont.)	Supported Liquid Membrane REMA-124	**Pre-demonstration** The process can achieve large concentration factors and show good selectivity when the appropriate extractant is used. Tc was reduced form 786 to 2 pCi/L in one series of tests.	Basic research to determine effective carriers. Design, testing, and scale-up needed at all levels. Extractant loss needs quantification.	Normal Operating costs should be reasonable; Extractant (carrier) volumes are low and the process is simple. Costs are unknown but may be moderate, perhaps $10M/1000 gal. Development costs could be a few $M.
	In Situ Reduction and Fixation REMA-125	**Evolving** In situ application. Potentially low cost, perhaps <$1/1000 gal. Waste volume would be minimal.	Both the ability to reduce Tc effectively in situ and the long-term retentior of Tc needs to be established.	Even if good Tc retention is demonstrated, the regulatory acceptance of the method must be established. Questions are likely to involve the long-tern stability of the retention. How long can the Tc be maintained in the less soluble reduced state? Is it acceptable to leave the radioactivity in the soil, even if it is not leaching? Development and testing could cost a few $M.
Chemical Separation	Adsorption on Activated Carbon REMA-111	**Accepted** for similar application. Retention, capacity, and selectibity for toxic metals on K-25 waters needs to be demonstrated. Costs should be moderate (a few $/1000 gal). Waste volume depends on regeneration system. Waste handling costs could be high of capacities are low.	Establish applicability to K-25 waters. Evaluate regeneration and waste volume (bed capacity).	Normal Development/demonstration costs for K-25 waters could be <$1M.
	Precipitation REMA-112	**Accepted** for other applications. Cost reported to be $353/1M gal for iron precipitation. Waste handling for K-25 waters could increase costs considerably. Waste volume - large. Because of waste volume, this is only likely to be used for high concentration problems.	Evaluate long-term stability of sludge and methods for handling sludge waste.	Normal

Technology Logic

Remedial Actio[n]

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternati[ves]
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Groundwater, Surface Water →	Heavy Metals in Groundwater (Hg, Cr) →	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified. →	Treatment →	Chemical Separation (cont.)

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA) → Contaminated Groundwater, Surface Water
- Waste Management (WM)

Logic Diagram
ial Action

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Separation (cont.)	Reverse Osmosis REMA-113	**Accepted** Usually removes most dissolve matter; not specific for different metals. Moderately expensive (probably several dollars per 1000 gal). Treatment of concentrate will add to costs. Waste volume depends upon method used to treat concentrate.	Treatability tests for specific waste waters. Determine degree of concentration to avoid precipitation. Identify methods for handling concentrate. Limited further development to test new membranes and K-25 waters may be needed.	Normal Development <$1m.
	Biosorption REMA-114	**Pre-demonstration** Method involves incorporation of biological materials, specific to a given contaminant, into a polymer matrix. Lab and bench scale only, to date. Essentially complete removal possible, but at what loading? Costs expected to be low. Waste volume depends upon loading capacity of biosorbent and waste handling/regeneration method used.	An emerging technology with concommitant basic research needs.	Normal Development/demonstration costs could be moderate (a few $M).
	ion-exchange REMA-115	**Accepted** Essentially any level of removal is possible, but costs could become excessive. Capital costs for complete mobile ion-exchange treatment system for groundwater estimated at $786,800. Operating costs reasonable, but resin waste treatment costs may be significant.	Tests with K-25 waters. Evaluate selectivity. Evaluate regeneration methods and/or waste minimization.	Normal Development/demonstration costs could be modest, perhaps <$1M.
	Oxidation/Precipitation with Ozone REMA-116	**Predemonstration** Technique can work only for some metals. The technology is currently mostly an idea. Costs could be moderate, perhaps a few dollars per 1000 gal. Wastes would be the precipitated material and associated solids. Selectivity of the precipitations could reduce waste volume somewhat.	Much testing needed. Determine co-precipitation of metals. Practical systems need to be demonstrated with K-25 waters.	Normal. Effectiveness of the method must be established, handling and treatment of the precipitates must be addressed. Cost to develop and test the concept could be a few $M.

Technology Log

Remedial A

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Groundwater, Surface Water	Chlorinated Volatile Organic Compunds (VOCs) in Groundwater	Refer to Volume1, Chapter 10, for potentially [illegible]licable proposed and pr[illegible]gated environmental law[illegible] [illegible]igned and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site-and waste-specific characteristics are provided for each technology, specific regulatory requirements [illegible] specified.	Treatment	Physical Separati Chemica Separati

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram
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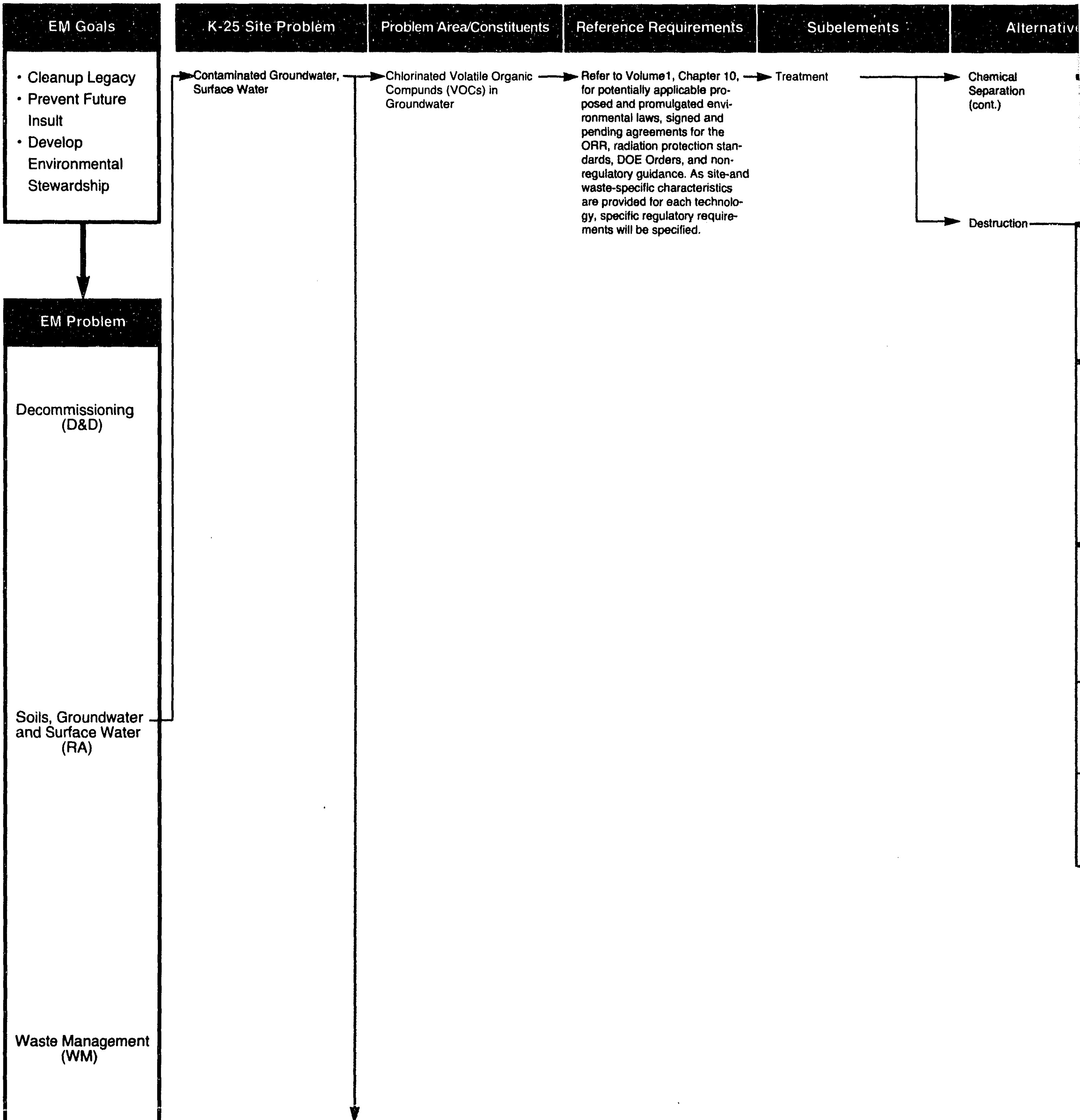
Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Separation	In Situ Air Stripping REMA-41	**Accepted** Well established technology. Major questions on performance concern effective contact of air with all of the contaminated water. Costs are usually low, perhaps even <$1/1,000 gal. treatment of off-gas can be a major cost. Waste volumes can be low, depends upon the off-gas treatment system.	Most improvements could be made in emissions control and minimization of wastes from emissions control system.	
Chemical Separation	Adsorption on Activated Carbon REMA-42	**Accepted** Several small scale units installed. Effectiveness is demonstrated; lower costs desired. Capital costs should be low, perhaps a few dollars per 1,000 gal. Operating cost and waste generation depend upon regeneration/disposal procedure. Presence of PCBs or radioactivity could prohibit "off-site" regeneration.	Treatability studies needed to determine effects of other contanimants. Low cost regeneration should be considered.	Normal
	Membrane Separations REMA-44	**Demonstrated** (several processes). Reverse osmosis used in municipal water and food industries. Pervaporation is gaining uses. Removal efficiencies needed for K-25 waters. Costs are low if there are not fouling problems or membrane degradation problems, usually less than $1.00/1000 gal. Waste volumes depend upon treatment of the reject (reverse osmosis) stream. These processes produce a liquid concentrate, not a solid waste.	Treatability tests needed to identify potential fouling problems. Membrane life expectancy needed. Methods needed for handling the concentrate stream.	Normal Further development need for each method, perhaps a few $M.
	Lime Coagulation REMA-46	**Demonstrated** Standard water treatment step; can reduce VOC content. Adsorption on precipitate and evaporation may be difficult to tell apart. Removal efficiency is uncertain. Method probable would not be used specifically for VOCs. A low cost treatment, but significant waste generation. Direct treatment costs will be low (probably <$1.00/1000 gal.). Waste handling/disposal costs could be high. Probably of most interest if coagulation is needed for other purposes; VOC removal would be additional benefit.	Assess coagulation of materials in K-25 waters; explore waste treatment. Determine fate of removal VOCs.	Normal

Technology Logic

Remedial Actior



Logic Diagram
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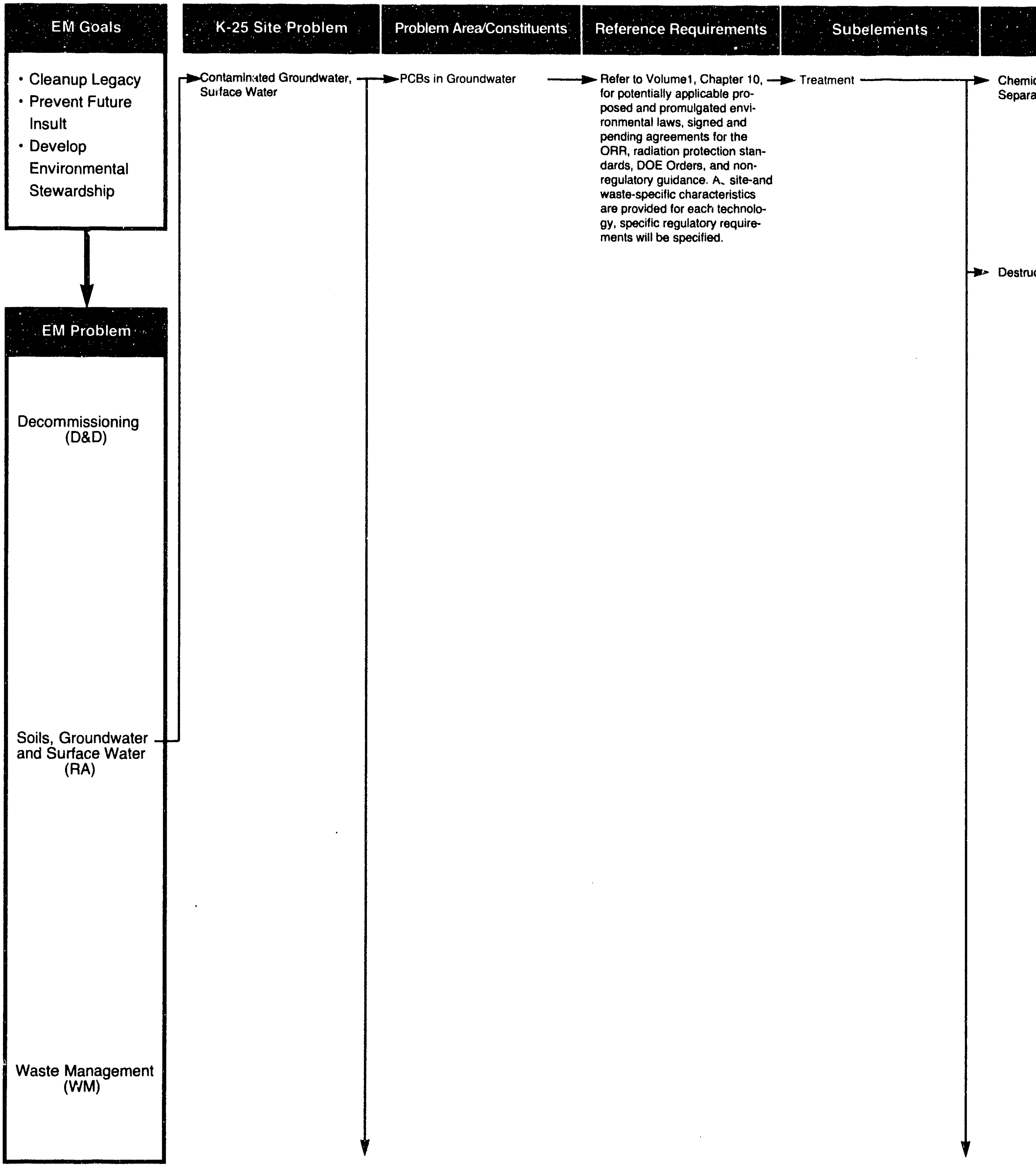
Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Separation (cont.)	Chemical Dechlorination with Iron REMA-49	**Pre-demonstration** Initial tests made at one site. Merits are still speculative. Material balances needed. Large-scale and realistic testing needed. Cost are speculative, but could be low. Waste volume will be low if residual iron is not considered a hazardous waste.	Understanding of rate controlling steps and how the rates are affected by solution and iron properties. Good material balances (possibly with radio-tracers) to confirm that dechlorination is taking place.	Normal Development/demonstration costs could be a few $M.
Destruction	UV Enhanced Chemical Oxidation REMA-43	**Demonstration/Accepted** High efficiencies achieved. Greatly reduces load on carbon bed polishing system. Commercially available. Costs reported to be low (less than $1.00/1000gal. Waste volume minimal.	Look for interferring components in K-25 waters. Avoid "fouling" of light transmitting surfaces.	Normal
	Ex Situ Biodegradation REMA-47	**Demonstration** A demonstration is in progress at K-25. Similar demonstrations at other DOE sites. Removal rates are not adequate for all compounds. Costs are likely to be low, but will depend upon degradation rates (reactor size). Waste volume should be small, excess biological materials.	Determine threshold of PCE and TCE inhibition. Better reactor designs and better understanding of the biological processes.	Normal Development/demonstration costs could be a few $M.
	Chemical Oxidation REMA-48	**Accepted** Commercially available. Different oxidants available. Catalysts often used. Costs expected to be low, a few dollars per 1,000 gal. depend upon total material oxidized. Waste volume minimal.	Treatability tests and pilot units recommended to confirm rates and consumption of oxidants, other materaisl will be oxidized.	Normal.
	Corona Discharge REMA-130	**Evolving/Preconceptual** Destruction mechanism not understood. No performance reported. Waste: likely to be small.	Development of firm basics for technology.	Normal. A few million for evaluation and demonstration.
	Ultrasound REMA-131	**Evolving/Preconceptual** Costs: estimated to be a few $/100gal. No performance reported Wastes: likely to be small.	Development of firm basics for technology.	Development costs may be a few $ million.
	Electron Beam REMA-132	**Pre-demonstration** Costs may be high. No performance reported Wastes: likely to be small.	Beam current, beam voltage requirements needed.	Projected capital operating costs high.

Technology Log

Remedial A.



Logic Diagram
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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Separation	Adsorption on Carbon REMA-101	**Accepted.** Commercially available. Effective, but costly. Most desired removal efficiencies can reached, at a cost. Costs can be high if the carbon beds cannot be regenerated but are treated as waste. Waste volumes will be large if beds are not regenerated.	Better regeneration and PCB recovery methods, preferrably for use on-site.	Normal Development/demonstration of new regeneration approaches could cost a few $M.
Destruction	Biodegradation REMA-102	**Pre-demonstration** Uncertain probability of success. PCBs are refractory compounds, difficult to degrade. Too early to estimate costs, could be low. Waste volumes should be small.	Better approaches to the more highly chlorinated compounds. more rapid anaerobic dechlorination rates. Confirm presence of degradation products. Evaluate toxicity of degradation products.	Normal Development costs could be several $M.
	Chemical Oxidation REMA-103	**Pre-demonstration** Work on other chlorinated compounds may be helpful. UV-peroxide oxidation is nearing acceptance. Waste volume should be low. If standard methods are for PCBs, the costs could be low ($1 or a few dollars per 1,000 gal.)	Insurance of complete degradation and proper reagent doses.	Normal Futher development/demonstration costs could be a few $M.
	Chemical Dechlorination with Iron REMA-104	**Pre-demonstration** Initial tests made at one site. Merits are still speculative. Need good material balance, and proof of dechlorination. Large-scale and realistic testing needed. Costs are speculative, but could be low. Waste volume will be low if residual iron is not considered a hazardous waste.	Understanding of rate controlling steps and how the rates are affected by solution and iron properties. Material balances with radio tracers.	Normal Development/demonstration costs could be several $M.

Robotics/ Autor

The identification of the technologies required to use robotics/ automation in the d
25 was based upon the premise that the primary purpose of these technologies is to
ization, decontamination, and dismantlement. Hence, in this section of the diagram t
ing activities and no attempt to differentiate between activities was made. For examp
be equally applicable to deploy dismantlement tools.

The robotics/ automation technologies were grouped into three main categories: (
groups identified under each of the categories. Technologies were selected for this s
economy in the deployment of tools and sensors, adaptability of automated equipme
elimination of clothing exchange requirements, and reliability and efficiency in handli

/ Automation

nation in the decommissioning, remedial action, and waste management at K-
ınologies is to provide support for other necessary activities such as character-
the diagram the problem areas are identified as these “other” decommission-
de. For example a robotic platform used to deploy a sensor was assumed to

n categories: (1) Mechanical, (2) Control, and (3) Sensors; with various sub-
ected for this section on the basis of the following considerations: speed and
ıated equipment to repetitive tasks, ability to minimize waste by reduction or
ency in handling redundant tasks.

Technology Logic

Robotics/Automa[t]

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

Enrichment Process Buildings

Process Support Buildings

Cooling Towers

Electrical and Electrical Switch Gear

Pumping Stations

Laboratory Facilities

Special Development Facilities

Administrative Facilities

Problem Area/Constituents

I. CHARACTERIZATION
a. Provides methods of deploying sensors and instruments required under **Alternatives**: "Sampling,", "In-Situ Chemical," and "In-Situ Physical."
b. Provides methods for the automation of analytical laboratory operations including **Alternatives:** "Sample Preparation," "Data Collection/Data Management," and "Ex-Situ Chemical."

II. DECONTAMINATION
a. Provides methods of deploying tools or performing operations which would increase the efficiency of operations as in **Alternative** mechanical substrate surface removal.
b. In-situ decontamination technologies that generate secondary environmental hazards, for example, grinding (DCON-43 & 44-OG), plasma torch (DCON-72-OG), carbon dioxide blasting (DCON-39-OG), etc.

III. DISMANTLEMENT
a. Provide methods of deploying the tools or performing the operations necessary for the dismantlement of facilities or equipment to increase their cost effectiveness or protect cleanup personnel.

Abrasive High Pressure Water Jet (DISM-11, 35, 52, &59-OG)
Diamond Wire Cutting (DISM-12-OG)
Microwave Scabbing (DISM-31-OG)
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Conventional Disassembly (DISM-33-OG)
Advanced Automatic Fixtures (DISM-57-OG)
Plasma Arc Cutting (DISM-36-OG)
Grabbler for Remotely Cutting Metals (DISM-43 & 58-OG)
Vacuum Systems (DISM-46 & 47-OG)
Positioning of Equipment Using Laser/Bar Codes (DISM-54-OG)

IV. WASTE MANAGEMENT
Provide automated or remotely operated methods of processing hazardous wastes, particularly those that lead to waste forms that are highly radioactive. Examples of these processes are described in WPRO-102, 109, 112, 115, 202, 219, & 303-OG.

V. REMEDIAL ACTION
a. *Provide remotely operated or* robotic devices (e.g. excavators, front-end loaders, scrappers, etc) to collect the large quantities of contaminated soils for those remedial actions described, for example in REMA-11, 37, 51, 53, 56, 58, 63, 64, 65, 69, 74, 76, 77, 83, 84, & 111-OG.

Reference Requirements

Subelements

Robotics/Automation

Alternat[ives]

1A. Mechanical Mc[...]

1B. Mechanical – Manipulation

ogic Diagram
utomation

Alternatives	Technologies (And Requirements When Applicable)	Status	Science/Technology Needs	Implementation Needs
1A. Mechanical Mobility	Wheeled/Tracked Vehicle • Heavy Duty (>1,000 lbs) • Medium Duty (100-1,000 lbs) • Light Duty (<100 lbs) ROBA-1-OG	**Accepted** **Efficacy:** High; agility may be restricted for larger systems. Normal deployment method for characterization and decontamination tasks. Such vehicles are presently in use. **Waste:** Possible emission; decontamination of system after use.	Technology Development: • Improved controls to allow more autonomy. Such improvements would permit fewer than one operator per machine.	No unusual implementation needs. **Development Cost:** $100K-$300K/application **Capital Costs:** $75K-$300K/per vehicle **Operating Costs:** $250K-$400K/machine/year
	Pipe/Duct Crawler A Internal ROBA-2-OG B External ROBA-3-OG	**Pre-Demonstration** **Efficacy:** High for mobility if obstacles aren't present. **Waste:** Decontamination of system after use.	Technology Development: • Miniaturization of Sensors/Tooling • Robotic Compatibility of Tooling • Obstruction Removal or By-Pass	No-unusual implementation needs. Development costs: $1-2M **Capital Costs:** $250K-$1M/machine **Operating Costs:** $250K/machine/year
	Bridge-Mounted Robotic Platform ROBA-4-OG	**Accepted** **Efficacy:** High; Particularly useful for dismantlement and movement of equipment to work cells. **Waste:** Little or None	None	Standardization of robotic platforms and improved remote maintenance methods to minimize waste generation. **Development Costs:** $0K **Capital Costs:** $100-$200K/application
	Power Sources for Mobile Platform • Batteries/Fuel Cells • Internal Combustion • Umbilical Cord ROBA-5-OG	**Accepted** (Batteries) **Demonstration** (Fuel Cells) **Accepted** (Internal Combustion) **Accepted** (Umbilical Cord) **Efficacy:** High for internal combustion and umbilical; Medium for batteries and fuel cells. **Waste:** Batteries/Fuel Cells, possible chemical waste; Internal combustion emissions; Decontamination of umbilical after use.	Technology Improvement: • Energy Storage Capacity • Duty Cycle Availability • Current Capacity/Discharge Rate • Emission Control • None	Improvements in batteries and fuel cells should utilize capabilities of industrial partners. Costs for Power Sources are included in costs identifies for the robotic platforms. (e.g. AUTO-1,-2,-3)
	Failure Recovery • Redundant Drives • Tethers ROBA-6-OG	**Accepted** (Redundant Drives) **Efficacy:** Medium, Increased system complexity. **Waste:** Little or None Accepted (Tethers) **Efficacy:** High; Particularly for uncluttered areas. **Waste:** Decontamination of system after use.	None None	Normal implementation needs. **Capital Costs:** <$50K/application. No identifiable development or operating costs.
1B. Mechanical Manipulation	Long Reach Arms (2-20 Meters) A Heavy Duty (>500 lbs. Payload) ROBA-9-OG B Medium Duty (50-500 lbs. Payload) ROBA-8-OG C Light Duty (<50 lbs. Payload) ROBA-7-OG	**Demonstration** **Efficacy:** Medium, Accurate positioning is more difficult as size and payload increases. Alternative is tele-operated system. **Waste:** Possible hydraulic fluid; Decontamination of system after use.	Technology Development: • Flexible Body Control • End-Point Sensing • Collision Avoidance • Weight-To-Payload Ratio Reduction • Light Weight Small Cross Section Design (Light Duty)	Normal implementation needs. Development Costs: $2-10M **Capital Costs:** $1-5M/manipulator **Operating Costs:** $200-500K/year/manipulator
	Arms with > 6 Degrees of Freedom • Positioning Accuracy <1inch • Force Reflection • Modular Construction ROBA-10-OG	**Demonstration** **Efficacy:** High; Useful for cluttered areas not accessible to suited workers **Waste:** Possible hydraulic fluid, Decontamination of system after use. Total waste volume would be small (<5gal.)	Technology Development: • Redundant Task Planning and Control • Modular Design • Real-Time Master/Slave Operation	Normal implementation needs. **Development Costs:** $1-5M **Capital Costs:** $500K-$1M/manipulator **Operating Costs:** $250K/manipulator/year

Technology Lo

Robotics/Auto

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

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- Administrative Facilities

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Subelements

Robotics/Automation (cont)

A

- 1B. Mech Mani
- 1C. Mech End-E
- 1D. Mech Separatio Material F
- 2A. Contr

Logic Diagram

ɜ/Automation

Alternatives	Technologies (and requirements when applicable)	Status	Science/Technology Needs	Implementation Needs
1B. Mechanical Manipulation	Compact, High Capacity Arms ROBA-11-OG	**Evolving Tech** - Conceptual **Efficacy:** Medium, Packaging of resulting systems for constrained areas will be difficult. **Waste:** Decontamination of hardware after use. Total waste volume would be <5 gal. per application.	Science Need: High Power Density Motors	No unusual implementation needs. **Development Costs:** $1-2M **Capital Costs & Operating Costs** are identified in other technologies (e.g. AUTO-7 &9).
1C. Mechanical End-Effectors	Multi (>2) Fingered ROBA-12-OG	**Pre-Demonstration** **Efficacy:** High with good control algorithms, however usefulness for D&D is limited. **Waste:** Decontamination of hardware after use.	Technology Development: • Compact Distributed Sensors & Electronics • Control Algorithms	Normal implementation needs. **Development Costs:** $1-2M **Capital Costs:** $100K-$500K **Operating Costs:** Negligible, absorbed in system operating costs.
	Remotely/Automated Interchangeable of End-Effectors ROBA-23-OG	**Demonstration** **Efficacy:** High; Particularly useful for dismantlement tasks. **Waste:** Decontamination of hardware after use. Minimal waste volume (<5 gal.)	None	Normal implementation needs. **Capital Costs:** $50K-$100K **Operating Costs:** Negligible, absorbed in system operating costs.
	Tool-Arm Interface ROBA-24-OG	**Demonstration** **Efficacy:** High; Requires cable management for tool resources. Particularly useful for decon. & dismantlement. **Waste:** Decontamination of hardware after use. Minimal waste volume.	None	Normal implementation needs. **Capital Costs:** $50K-$100K **Operating Costs:** Negligible, absorbed in system operating costs.
	Force Limiter ROBA-25-OG	**Demonstration** **Efficacy:** High; Primary application in automated laboratory. **Waste:** Decontamination of hardware after use.	None	Normal implementation needs. **Capital Costs:** $50K-$100K **Operating Costs:** Negligible, absorbed in system operating costs.
1D. Mechanical: Automated Separation Technologies for Material Recovery	Magnetic Separators ROBA-26-OG	**Accepted** (Magnetic vs.Non-Magnetic materials) **Efficacy:** High; for separation of ferro magnetic materials from non-magnetic alloys. **Waste:** Decontamination of hardware after use.	None (Mag. vs. Non-Mag.)	**Capital costs:** $75-$150K/ system **Development Costs:** $0.5M-$1.0M **Operating Costs:** $200K/year/system
		Evolving Tech-Conceptual for other Material Combinations **Efficacy:** TBD; If feasible, could be very useful for recovery of valuable, ferro magnetic materials. **Waste:** Decontamination of hardware after use.	Science Need: (other material combination) •Theoretical Analysis/Selection of Components • Bench Scale Tests • System Design for High Thru-Put	(same as above)
2A. Control: Algorithms	Multiple, Concurrent Mobile Platform Control ROBA-27-OG	**Pre-Demonstration** **Efficacy:** High, greatly increases operator efficiency, high pay-off technology. **Waste:** N/A; no waste generated by control system.	Science Development: • Decentralized, Semi-Autonomous Control • Greater Computational Thru-Put	Personnel Training on a high fidelity simulator may be required. **Development Costs:** $1.0M-$3M **Capital Costs:** $0.5M-$1.0M **Operating Costs:** $300K-$500K/year/system
	Combined Mobility/Manipulation/ End Effector Control ROBA-28-OG	**Demonstration** **Efficacy:** High, Increases operator efficiency for complex geometrics. **Waste:** N/A; no waste generated by control system.	Science Development: • Real-Time Task Planning Technology Development: • Task Definition • Software Development	Personnel Training **Development Costs:** $0.5M-$1.5M **Capital Costs:** $0.2M-$0.5M **Operating Costs:** $200K-$300K/year/system

Technology Logic I

Robotics/Automation Te

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

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- Process Support Buildings
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Problem Area/Constituents

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Vacuum Systems (DISM-46 & 47-OG)
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Reference Requirements

Subelements

Robotics/Automation (cont.)

Alternatives

2A. Control: Algorithms (cont.)

2B. Control: Man-Machine Interface

Logic Diagram

utomation Team

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
2A. Control: Algorithms (cont.)	Pre-Programmed Obstacle Avoidance ROBA-29-OG	**Accepted** **Efficacy:** High with good model of workspace. High pay-off technology when combined with ROBA-27-OG. **Waste:** None	Technology Improvement: • Effective man-machine supervisory interface.	No unusual implemental needs **Development Costs:** \$0.5M-\$1.0M **Capital Costs:** \$100K-\$400K **Operating Costs:** \$200K-\$300K/year/system.
	Programmed Motions (Per EPA Protocols) ROBA-30-OG	**Accepted** **Efficacy:** High; Similar to factory automation for analytical laboratory. **Waste:** None	Technology Improvement: • Ability to manipulate glassware • EPA approval of automated protocols.	No unusual implementation needs. **Development Costs:** \$0.5M-\$1.0M/protocol **Capital Costs:** \$200K-\$400K/protocol **Operating Costs:** \$200K-\$300K/year/system. (Note: This is an OTD Robotics activity.)
	Sample Management ROBA-31-OG	**Demonstration** **Efficacy:** Medium; requires special support hardware. **Waste:** Decontamination of support hardware after use.	Technology Development: • Increased Reliability • Fault Recovery	Normal implementation needs. **Development Costs:** \$0.5M-\$1.0M **Capital Costs:** \$0.5M-\$1.0M **Operating Costs:** \$200K-\$300K/year/system.
2B. Control: Man-Machine Interface	Single Human-Multiple Vehicle Control Station ROBA-32-OG	**Pre-Demonstration** **Efficacy:** High; Similar to ROBA-27-OG. High pay-off technology. **Waste:** N/A	Science Development: • Embedded Intelligence • Multi-Modal Interface Technology Development: • Effective Supervisory Control	Normal implementation needs. **Development Costs:** \$1.0M-\$3.0M **Capital Costs:** \$0.5M-\$1.0M **Operating Costs:** \$300K-\$500K/year/system.
	Data Fusion ROBA-33-OG	**Demonstration** **Efficacy:** High; can compensate for failed sensors. **Waste:** None	Science Development: • Data Verification • Techniques for Functioning with Missing Data	No unusual implementation needs. **Development Costs:** \$0.5M-\$2.0M **Capital Costs:** \$0.1M-\$0.5M **Operating Costs:** \$200K-\$300K/year/system.
	Teach/PlayBack ROBA-34-OG	**Accepted** **Efficacy:** High, similar to factory automation. Requires reliable position sensors. **Waste:** None	Science Improvement: • Expansion of Performance List Technology Improvement: • Increased Precision and Speed	No unusual implementation needs. **Development Costs:** \$0.5M-\$1.0M **Capital Costs:** \$200K per system **Operating Costs:** Included in control system costs.
	Voice Control ROBA-35-OG	**Accepted** **Efficacy:** Medium, stated improvement needs could move to high. Particularly useful for supervisory control of multiple systems. **Waste:** None	Science Improvement: • Language Expansion • Multiple Operator Recognition	Specialized Operator Training (~1MM per operator) may be required. **Development Costs:** \$0.5M-\$1.0M **Capital Costs:** \$100-\$300K/station **Operating Costs:** Included in control system costs
	Man-Robot Symbiosis ROBA-46-OG	**Pre-Demonstration** **Efficacy:** Medium to low. Significant development required and potential applications are limited. **Waste:** None	Science Development: • Machine Learning • Dynamic Task Allocation	Operator training may be extensive. **Development Costs:** \$2.0M-\$4.0M **Capital Costs:** TBD **Operating Costs:** TBD

Technology Loç

Robotics/Autc

EM Goals

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EM Problem

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K-25 Site Problem

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Reference Requirements

Subelements

Robotics/Automation (cont.)

A

2B. Cont Interf (cont.)

2C. Cont Trans

3A. Sens Perc

2B. Control: Man-Machine Interface (cont.)	Fuzzy Control ROBA-47-OG	**Demonstration** **Efficacy:** Medium. Again could be useful for supervisory control of multiple systems. Development costs are high and applications are limited. **Waste:** None	Science Development: • Calibration of Fuzzy Rule Bases • Emulation of Human Logic • Integration with Other Control Types	No unusual implementation needs. **Development Costs:** $1.0M-$3.0M **Capital Costs:** $0.5M-$1.0M/station **Operating Costs:** Negligible
	Transportable Control Stations ROBA-48-OG	**Accepted** **Efficacy:** High, necessary for decommissioning activities. **Waste:** None	Technology Development: • Field-Hardening • Improved Reliability/Durability	Normal implementation needs. **Development Costs:** $200K-$400K **Capital Costs & Operating Costs:** Included in system costs.
2C. Control: Signal Transmission	Hard-wire (umbilical) ROBA-49-OG	**Accepted** **Efficacy:** High, Some limitation in large cluttered areas. **Waste:** Decontamination after use.	None	No implementation needs. Costs are negligible.
	Microwave ROBA-50-OG	**Demonstrated** **Efficacy:** High, although may require line-of-sight between transmitter-receiver. **Waste:** None	Technology Improvement: • Robust, multi-path operation in reflective environment.	Normal implementation needs. **Development Costs:** $600K-$800K **Capital Costs:** $200K/system **Operating Costs:** Included in cost of control system.
	Radio (RF) ROBA-51-OG	**Demonstrated** **Efficacy:** Medium. Multiple units likely needed for bandwidth requirements. **Waste:** None	Technology Improvement: • Robust, multi-path operation in reflective environment.	Normal implementation needs. **Development Costs:** $0.5-$0.7M **Capital Costs:** <$50K/system **Operating Costs:** Included in control station costs.
	Laser ROBA-52-OG	**Accepted** **Efficacy:** Low, Requires line-of-sight, hence, usefulness is limited at K-25. **Waste:** None	None	None **Development Costs:** $0K **Capital Costs:** <$50K/system **Operating Costs:** Included in control station costs.
3A. Sensors: Perception	Vision A 3D ROBA-53-OG B HDTV ROBA-54-OG	**Demonstrated** **Efficacy:** Medium (both A & B) Applications may be limited at K-25. Maybe useful for cylinder yard inspections. **Waste:** None	Science Development: • Sensor Fusion • Advanced Visualization Capabilities Technology Improvement: • Environmental Hardening	Normal implementation needs. **Development Costs:** $0.5-$0.7M (3D) $0.3M-$0.5M (HDTV) **Capital Costs:** $300K per unit (3D) $200K per unit (HDTV) **Operating Costs:** Negligible
	Audio (Directional) ROBA-65-OG	**Demonstration** **Efficacy:** Medium to low. Applications at K-25 would be limited. **Waste:** None	Technology Improvement: • Representation To Operator • Integration with Other Sensors (Sensor Fusion) • Increased Processing Speed	Normal implementation needs. **Development Costs:** $0.5-$1.0M **Capital Costs:** $200K per unit **Operating Costs:** Negligible
	Force ROBA-66-OG	**Accepted** **Efficacy:** High for application in analytical laboratory. **Waste:** None	Science Development: • Improved Tactile Sensitivity	Normal implementation needs. **Development Costs:** $200K-$400K **Capital Costs:** $200K/unit **Operating Costs:** Negligible
	Imaging and Image Processing ROBA-67-OG	**Pre-Demonstration** **Efficacy:** Medium. Useful for inspection tasks (e.g. cylinder yards) **Waste:** None	Science Development: • Processing Speed • Presentation To Operator • Data/Sensor Fusion	Operator Training (~3MM per operator) **Development Costs:** $0.5-$1.0M **Capital Costs:** $300K-$500K/unit **Operating Costs:** Included in cost of control station.

Technology Logi
Robotics/Autom

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alter

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Subelements

Robotics/Automation (cont.)

Alter

3A. Sensors: Perception (cont.)

3B. Sensors: Control

Logic Diagram
s/Automation

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
3A. Sensors: Perception (cont.)	Wall Thickness • Ultrasonic • Eddy-Current ROBA-68-OG	**Status:** TBD **Efficacy:** TBD **Waste:** TBD	TBD	TBD
3B. Sensors: Control	Proximity ROBA-69-OG	**Pre-Demonstration** **Efficacy:** High for small volume coverage. Low for large area coverage. May be useful to alert supervisory operator of impending collision. **Waste:** None	Technology Improvement: • Improved Sensor Range & Signal Quality	Normal implementation needs. **Development Costs:** $1.0-$2.0M **Capital Costs:** $200K-$300K/unit **Operating Costs:** None
	Positioning ROBA-70-OG	**Pre-Demonstration** **Efficacy:** Medium for high accuracy, real-time navigation within building structures. **Waste:** None	Technology Improvement: • Improved Accuracy by Combining with Dead-Reckoning	No unusual implementation needs. **Development Costs:** $0.5-$1.0M **Capital Costs:** $200K-$300K/unit **Operating Costs:** Included in control system costs.
	Laser Range Finders ROBA-71-OG	**Pre-Demonstration** **Efficacy:** Medium for object recognition. 3D mapping of task sites. **Waste:** None	Technology Improvement: • Improved Reliability of Hardware • Data Interpretation	Normal implementation needs. **Development Costs:** $0.5-$1.0M **Capital Costs:** $250K/unit **Operating Costs:** Negligible
	Force Control ROBA-72-OG	**Pre-Demonstrated** **Efficacy:** High for cartesian or joint space sensing. Medium for tactile sensing. Particularly useful for laboratory sample handling. **Waste:** None	Technology Improvement: • Improved Tactile Sensing	Normal implementation needs. **Development Costs:** $0.2-$0.5M **Capital Costs:** $100K/unit **Operating Costs:** Negligible
	Liquid/Liquid Interface Detection for Phase Separation ROBA-73-OG	**Status:** TBD **Efficacy:** TBD **Waste:** TBD	Science Need: TBD	TBD
	Flow/Mass/Volume ROBA-74-OG	**Accepted** **Efficacy:** High for analytical laboratory **Waste:** Possible decontamination after use.	None	Normal implementation needs. **Development Costs:** $0K **Capital Costs:** $<20K/unit **Operating Costs:** Negligible
	Position Sensors for Manipulator and End-Effectors ROBA-75-OG	**Accepted** **Efficacy:** High for analytical laboratory. **Waste:** None	None	Normal implementation needs. **Development Costs:** $0K **Capital Costs:** $<10K/unit **Operating Costs:** Negligible

Waste Mana

The Waste Management (WM) section of the TLD focuses on addressing th ed as a result of the decontamination and decommissioning (D&D), remedial ac tives of the WM wiring diagrams are to enumerate and evaluate the likely WM o from most effective to least effective in managing wastes. The WM wiring diagr they relate to the K-25 Site D&D and RA activities: Waste Retrieval, Waste Proc Transportation, Waste Disposal, and Waste Minimization.

It should be noted that Waste Stabilization, as used in the K-25 Site Technol residual solid wastes and does not include pretreatment of the wastes to stabili

lanagement

;essing the technologies for processing the waste streams likely to be generat-
medial action (RA), and current WM operations at the K-25 Site. The objec-
:ely WM options and to rank these options in three broad categories ranging
ring diagrams were developed to address the following "EM Problem" areas as
/aste Processing, Waste Stabilization, Waste Packaging, Handling, &

e Technology Logic Diagram, consists of processes for the final treatment of
· to stabilize them before WM operations.

Technology Logi

Waste Managem

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternat
• Historical Waste Disposal Sites • Burial Grounds • Acid Pits • Retention Basins • Bulk Waste in Storage Tanks	• RAD • Scrap Wood • Scrap Metals • Asbestos • PCBs • Organics • Inorganics	• TSCA PCB FFCA • RCRA LDR FFCA • CERCLA/SARA • Clean Water Act • Clean Air Act • DOE Orders	Waste Retrieval	• Mechanical Retri • Hydraulic Retriev

.ogic Diagram
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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
• Mechanical Retrieval →	**Wheeled/Tracked Vehicles** → – Front-end Loader – Backhoe – Fork Lift	See Robotics/Automation		
	Demolition → – Jackhammers – Controlled Blasting	See Dismantlement		
• Hydraulic Retrieval →	**Fluid Systems** →	See Dismantlement		

Technology Lo

Waste Manag

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
Contaminated Concrete Rubble →	• Decontaminated Bldgs. • Rubble • RAD • PCBs • Organics • Inorganics →	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified. →	Waste Processing →	Waste S Thermal Chemic

-ogic Diagram
anagement

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Waste Stabilization	See Waste Stabilization			
Thermal Treatment	Thermal Desorption WPRO-106-OG	**Accepted** This technology has been used by industry to remove and recover volatiles from contaminated media such as soils. The process is claimed to have a >99% removal efficiency for recovering volatile organic compounds (VOCs) from soil. The application of the process to treat other contaminated media (such as concrete rubble) needs to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application, funding, and regulatory approval.
	Plasma Arc Furnace WPRO-107-OG	**Demonstration** This is a developmental technology proposed for the destruction of organics and the immobilization of non-volatile radionuclides and toxic metals in a glassy slag matrix. The attractive features of the technology are that it can be used to treat almost any solid waste and it does not require extensive pre-treatment of the waste feed. The negative aspect of the process is that it is very energy intensive thus, it is likely to be expensive	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment. RD&D is required on the process to determine for example, waste destruction and removal efficiencies (DREs), electrode life, materials of construction, power efficiency, effluent characteristics for different waste feeds, and the viability of the process.	The RD&D effort is estimated to require 3 years and $ 10 million.
Chemical Treatment	Solvent Washing WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.

Technology Lo

Waste Manag

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Concrete Rubble	• Decontaminated Bldgs. • Rubble • RAD • PCBs • Organics • Inorganics	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Chemica
	Scrap Transite Scrap Asbestos Pipe & Insulation	• Asbestos • PCB • Oils • RAD • Organics • Inorganics	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Waste S Chemica

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram

anagement

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Treatment	Gamma-Radiolysis WPRO-100-OG	**Evolving Technology** The radiolytic destruction of halogenated and aromatic compounds at the laboratory scale is well documented. However, its application on an industrial scale needs additional RD&D. The process is capable of high (>90%) destruction efficiencies for organics.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment. Some of the issues to be resolved are the complete characterization of the radiolytic decomposition products under different conditions and for different waste materials and their relative toxicity. Another issue is the possibility of combining the radiolysis with enhanced biodegradation of the radiolytic byproducts.	The RD&D effort is estimated to require $ 1.25-2.5 million.
	Leaching & Stripping WPRO-213-OG	**Demonstration** This is an accepted technology in industry with removal efficiencies greater than 99% however, each application requires additional RD&D to determine optimum leachant composition and process conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	Demonstrate the effectiveness of the technology to meet the site requirements.
	Electro Osmosis/Migration DCON-20-OG	**Evolving Technology** Initial data indicate 90+% removal of uranium and technetium from concrete. The process could also be used to remove oils and organics however, this application needs additional RD&D.	Some development work is required to apply the method to treat the site wastes.	Normal implementation needs. Development costs are estimated to be $ 400-1000K. Capital costs: Not available. Operating costs: Likely to be more expensive than other waste treatment methods.
Waste Stabilization	See Waste Stabilization			
Chemical Treatment	Electro Osmosis/Migration DCON-20-OG	**Evolving Technology** Initial data indicate 90+% removal of uranium and technetium from concrete. The process could also be used to remove oils and organics however, this application needs additional RD&D.	Some development work is required to apply the method to treat the site wastes.	Normal implementation needs. Development costs are estimated to be $ 400-1000K. Capital costs: Not available. Operating costs: Likely to be more expensive than other waste treatment methods.

Technology Logic

Waste Manageme

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

Scrap Transite

Scrap Asbestos Pipe & Insulation

Problem Area/Constituents

- Asbestos
- PCB
- Oils
- RAD
- Organics
- Inorganics

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelements

Waste Processing

Alternativ

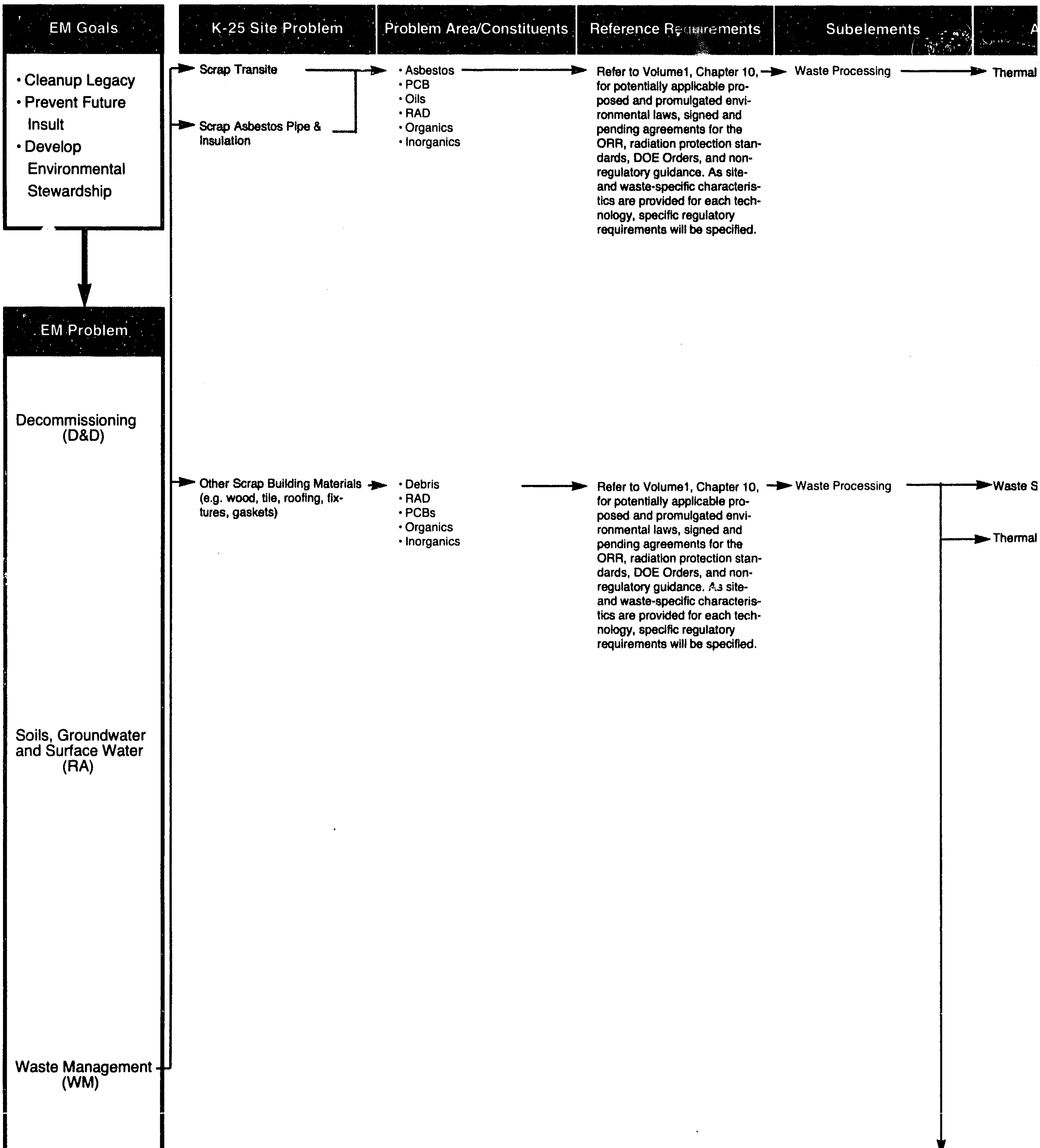
Chemical Treatment

Thermal Treatment

→ Chemical Treatment	→ Solvent Extraction WPRO-211/212-OG	→ **Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	→ Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	→ The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
	→ Gamma-Radiolysis WPRO-100-OG	→ **Evolving Technology** The radiolytic destruction of halogenated and aromatic compounds at the laboratory scale is well documented. However, its application on an industrial scale needs additional RD&D. The process is capable of high (>90%) destruction efficiencies for organics.	→ Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment. Some of the issues to be resolved are the complete characterization of the radiolytic decomposition products under different conditions and for different waste materials and their relative toxicity. Another issue is the possibility of combining the radiolysis with enhanced biodegradation of the radiolytic byproducts.	→ The RD&D effort is estimated to require $ 1.25-2.5 million.
→ Thermal Treatment	→ Incineration WPRO-108-OG	→ **Accepted** The EPA considers incineration to be the best demonstrated available technology (BDAT) for the destruction of organics. Incineration can achieve DREs greater than 99.999% for certain organics. However, additional RD&D on several aspects of incineration is still required.	→ Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated, Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	→ Knowledge of process application, funding, and regulatory approval. Insert 10: For example, the K-25 Site TSCA Incinerator is a 30 MMBtu/h unit that is permitted to destroy low-level radioactively contaminated mixed wastes. The unit was built at a capital cost of $ 26 million (1987 dollars). Obtaining regulatory approval for the TSCA Incinerator took over 8 years. The 1992 destruction costs at the incinerator are estimated to be $ 10 per pound of waste incinerated.
	→ Calcination/Roasting DCON-60-OG	→ **Demonstration** This is accepted industrial technology for the treatment of ores. However, its use for the removal and destruction of oils and organics from the site wastes needs to be demonstrated.	→ The use of the technology to meet the site requirements needs to be demonstrated.	→ The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.

Technology Lo

Waste Manag



Thermal Treatment (contd)	Catalytic Destruction WPRO-109-OG	**Pre-Demonstration** This technology has been demonstrated to be effective (DRE>99+%) for the destruction of liquid and gaseous organic wastes. However, its use to remove and destroy the organics from solids needs additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
	Plasma Arc Furnace WPRO-107-OG	**Demonstration** This is a developmental technology proposed for the destruction of organics and the immobilization of non-volatile radionuclides and toxic metals in a glassy slag matrix. The attractive features of the technology are that it can be used to treat almost any solid waste and it does not require extensive pre-treatment of the waste feed. The negative aspect of the process is that it is very energy intensive thus, it is likely to be expensive.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment. RD&D is required on the process to determine for example, waste destruction and removal efficiencies (DREs), electrode life, materials of construction, power efficiency, effluent characteristics for different waste feeds, and the viability of the process.	The RD&D effort is estimated to require 3 years and $ 10 million.
Waste Stabilization	See Waste Stabilization			
Thermal Treatment	Incineration WPRO-108-OG	**Accepted** The EPA considers incineration to be the best demonstrated available technology (BDAT) for the destruction of organics. Incineration can achieve DREs greater than 99.999% for certain organics. However, additional RD&D on several aspects of incineration is still required.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated, Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	Knowledge of process application, funding, and regulatory approval. Insert 10: For example, the K-25 Site TSCA Incinerator is a 30 MMBtu/h unit that is permitted to destroy low-level radioactively contaminated mixed wastes. The unit was built at a capital cost of $ 26 million (1987 dollars). Obtaining regulatory approval for the TSCA Incinerator took over 8 years. The 1992 destruction costs at the incinerator are estimated to be $ 10 per pound of waste incinerated.
	Plasma Arc Furnace WPRO-107-OG	**Demonstration** This is a developmental technology proposed for the destruction of organics and the immobilization of non-volatile radionuclides and toxic metals in a glassy slag matrix. The attractive features of the technology are that it can be used to treat almost any solid waste and it does not require extensive pre-treatment of the waste feed. The negative aspect of the process is that it is very energy intensive thus, it is likely to be expensive.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment. RD&D is required on the process to determine for example, waste destruction and removal efficiencies (DREs), electrode life, materials of construction, power efficiency, effluent characteristics for different waste feeds, and the viability of the process.	The RD&D effort is estimated to require 3 years and $ 10 million.

• Cleanup Legacy
• Prevent Future Insult
• Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

Other Scrap Building Materials (e.g. wood, tile, roofing, fixtures, gaskets)

• Debris
• RAD
• PCBs
• Organics
• Inorganics

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Waste Processing

Thermal Treatment

_ogic Diagram
anagement

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Thermal Treatment	Calcination/Roasting DCON-SL-10-OG	**Demonstration** This is accepted industrial technology for the treatment of ores. However, its use for the removal and destruction of oils and organics from the site wastes needs to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.
	Pyrolysis WPRO-110-OG	**Accepted** This is an accepted industrial process for the destruction of organics. The process has an organic destruction efficiency greater than 99%.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application, funding, and regulatory approval.
	Chem Char Process WPRO-114-OG	**Pre-Demonstration** This is a developmental technology based on coal char gasification. The process is claimed to achieve near total destruction of the organics and produces an inert char residue that contains the non-volatile toxic metals and radionuclides. This char residue can either be vitrified to yield a glassy slag or immobilized in cement.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
	Smelting WPRO-111-OG	**Demonstration** This is accepted industrial technology for the treatment and processing of metals. The technology has a DRE for organics greater than 99%. However, its use for the removal and separation of the radionuclides from the wastes requires additional RD&D. The process could be used for the removal of uranium from the waste but it may not be suitable for the removal of technetium. The disadvantage is that smelting may cause the surface radioactive contamination to become bulk contamination of the waste.	The use of the technology to meet the site requirements needs to be demonstrated.	The RD&D effort is estimated to require $ 3-5 million. The payback could be significant yielding a major waste minimization effort due to recovery and recycle of the metals.

Technology Lo

Waste Manag

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Other Scrap Building Materials (e.g. wood, tile, roofing, fixtures, gaskets) →	• Debris • RAD • PCBs • Organics • Inorganics →	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified. →	Waste Processing →	Chemic

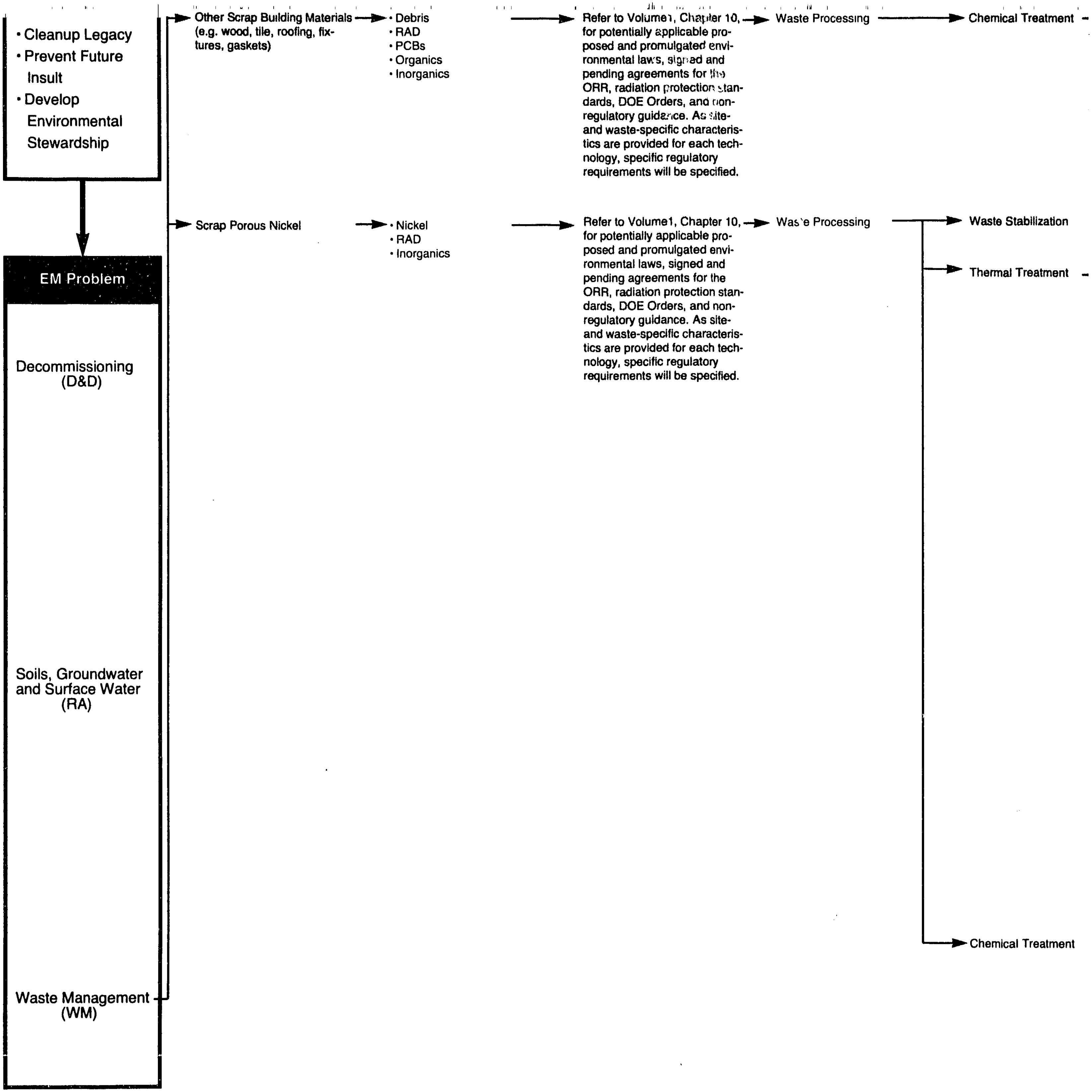
EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

Chemical Treatment	Solvent Extraction WPRO-111-OG	**Demonstration.** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
	Gamma-Radiolysis WPRO-100-OG	**Evolving Technology** The radiolytic destruction of halogenated and aromatic compounds at the laboratory scale is well documented. However, its application on an industrial scale needs additional RD&D. The process is capable of high (>90%) destruction efficiencies for organics.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment. Some of the issues to be resolved are the complete characterization of the radiolytic decomposition products under different conditions and for different waste materials and their relative toxicity. Another issue is the possibility of combining the radiolysis with enhanced biodegradation of the radiolytic byproducts.	The RD&D effort is estimated to require $ 1.25-2.5 million.
	Electro Osmosis/Migration DCON-20-OG	**Evolving Technology** Initial data indicate 90+% removal of uranium and technetium from concrete. The process could also be used to remove oils and organics however, this application needs additional RD&D.	Some development work is required to apply the method to treat the site wastes.	Normal implementation needs. Development costs are estimated to be $ 400-1000K. Capital costs: Not available. Operating costs: Likely to be more expensive than other waste treatment methods.


• Cleanup Legacy
• Prevent Future Insult
• Develop Environmental Stewardship
EM Problem
Decommissioning (D&D)
Soils, Groundwater and Surface Water (RA)
Waste Management (WM)
Other Scrap Building Materials (e.g. wood, tile, roofing, fixtures, gaskets)
• Debris
• RAD
• PCBs
• Organics
• Inorganics
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Waste Processing
Chemical Treatment
Scrap Porous Nickel
• Nickel
• RAD
• Inorganics
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Waste Processing
Waste Stabilization
Thermal Treatment
Chemical Treatment

-ogic Diagram
anagement

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Treatment	Leaching & Stripping WPRO-213-OG	**Demonstration** This is an accepted technology in industry with removal efficiencies greater than 99% however, each application requires additional RD&D to determine optimum leachant composition and process conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	Demonstrate the effectiveness of the technology to meet the site requirements.
Waste Stabilization	See Waste Stabilization			
Thermal Treatment	Smelting WPRO-111-OG	**Demonstration** This is accepted industrial technology for the treatment and processing of metals. The technology has a DRE for organics greater than 99%. However, its use for the removal and separation of the radionuclides from the wastes requires additional RD&D. The process could be used for the removal of uranium from the waste but it may not be suitable for the removal of technetium. The disadvantage is that smelting may cause the surface radioactive contamination to become bulk contamination of the waste.	The use of the technology to meet the site requirements needs to be demonstrated.	The RD&D effort is estimated to require $ 3-5 million. The payback could be significant yielding a major waste minimization effort due to recovery and recycle of the metals.
	Calcination/Roasting DCON-60-OG	**Demonstration** This is accepted industrial technology for the treatment of ores. However, its use for the removal and destruction of oils and organics from the site wastes needs to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.
	Mond Process WPRO-112-OG	**Demonstration** This is accepted technology for the refining of nickel. However its use to separate the nickel from some of the radionuclides (e.g., technetium) needs to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	The technology demonstration is estimated to require $ 1-2 million. The payback for the process is estimated to be greater than $ 20-30 million based on current disposal costs.
	Catalytic Destruction WPRO-109-OG	**Pre-Demonstration** This technology has been demonstrated to be effective (DRE>99+%) for the destruction of liquid and gaseous organic wastes. However, its use to remove and destroy the organics from solids needs additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
Chemical Treatment	Leaching & Stripping WPHO-213-OG	**Demonstration** This is an accepted technology in industry with removal efficiencies greater than 99% however, each application requires additional RD&D to determine optimum leachant composition and process conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	Demonstrate the effectiveness of the technology to meet the site requirements.

Technology Lo

Waste Manag

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Scrap Porous Nickel	• Nickel • RAD • Inorganics	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Chemic (contd)
	Scrap, Aluminum, Copper, and Other Non-Ferrous Metals (except Nickel)	• Aluminum • Non-ferrous metal • RAD • Organics • Inorganics	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Waste S Thermal

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Treatment (contd)	Gas Phase (ClF_3) Treatment DCON-16-OG	**Pre-Demonstration** Laboratory scale studies have shown that this process can effectively remove uranium deposits at room temperature. The process should also be effective in removing other radionuclides such as technetium. However, additional RD&D is needed to demonstrate the full capabilities of the process.	Knowledge of process application, funding, and regulatory approval. Development and demonstration of the optimum process conditions and unit operations for the removal of radioactive contaminants from the wastes and for the recycle of the reactant (ClF3).	The RD&D effort is estimated to require $ 5 million.
Waste Stabilization	See Waste Stabilization			
Thermal Treatment	Smelting WPRO-111-OG	**Demonstration** This is accepted industrial technology for the treatment and processing of metals. The technology has a DRE for organics greater than 99%. However, its use for the removal and separation of the radionuclides from the wastes requires additional RD&D. The process could be used for the removal of uranium from the waste but it may not be suitable for the removal of technetium. The disadvantage is that smelting may cause the surface radioactive contamination to become bulk contamination of the waste.	The use of the technology to meet the site requirements needs to be demonstrated.	The RD&D effort is estimated to require $ 3-5 million. The payback could be significant yielding a major waste minimization effort due to recovery and recycle of the metals.
	Incineration WPRO-108-OG	**Accepted** The EPA considers incineration to be the best demonstrated available technology (BDAT) for the destruction of organics. Incineration can achieve DREs greater than 99.999% for certain organics. However, additional RD&D on several aspects of incineration is still required.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated, Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	Knowledge of process application, funding, and regulatory approval. For example, the K-25 Site TSCA Incinerator is a 30 MMBtu/h unit that is permitted to destroy low-level radioactively contaminated mixed wastes. The unit was built at a capital cost of $ 26 million (1987 dollars). Obtaining regulatory approval for the TSCA Incinerator took over 8 years. The 1992 destruction costs at the incinerator are estimated to be $ 10 per pound of waste incinerated.
	Calcination/Roasting DCON-60-OG	**Demonstration** This is accepted industrial technology for the treatment of ores. However, its use for the removal and destruction of oils and organics from the site wastes needs to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.
	Catalytic Destruction WPRO-109-OG	**Pre-Demonstration** This technology has been demonstrated to be effective (DRE>99+%) for the destruction of liquid and gaseous organic wastes. However, its use to remove and destroy the organics from solids needs additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.

Technology Logi

Waste Managem

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Altern
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Scrap, Aluminum, Copper, and Other Non-Ferrous Metals (except Nickel)	• Aluminum • Non-ferrous metal • RAD • Organics • Inorganics	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Chemical Treat

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Treatment	Solvent Extraction WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
	NAC Process WPRO-105-OG	**Pre-Demonstration** The feasibility of the process has been proven at the bench-scale. If proven effective at the industrial -scale, the process could treat and dispose of all the contaminated aluminum from D&D operations. This aluminum would be used in the process to treat the radioactively contaminated nitrate wastes in the Hanford site tanks.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 2-5 million. The payback is expected to be significant especially because the scrap aluminum from the site can be used to dispose of the nitrate wastes in the Hanford site tanks. This is expected to result in significant savings due to minimizing the wastes to be disposed at the two sites.
	Gamma-Radiolysis WPRO-100-OG	**Evolving Technology** The radiolytic destruction of halogenated and aromatic compounds at the laboratory scale is well documented. However, its application on an industrial scale needs additional RD&D. The process is capable of high (>90%) destruction efficiencies for organics.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment. Some of the issues to be resolved are the complete characterization of the radiolytic decomposition products under different conditions and for different waste materials and their relative toxicity. Another issue is the possibility of combining the radiolysis with enhanced biodegradation of the radiolytic byproducts.	The RD&D effort is estimated to require $ 1.25-2.5 million.

Technology Lo

Waste Manag

EM Goals

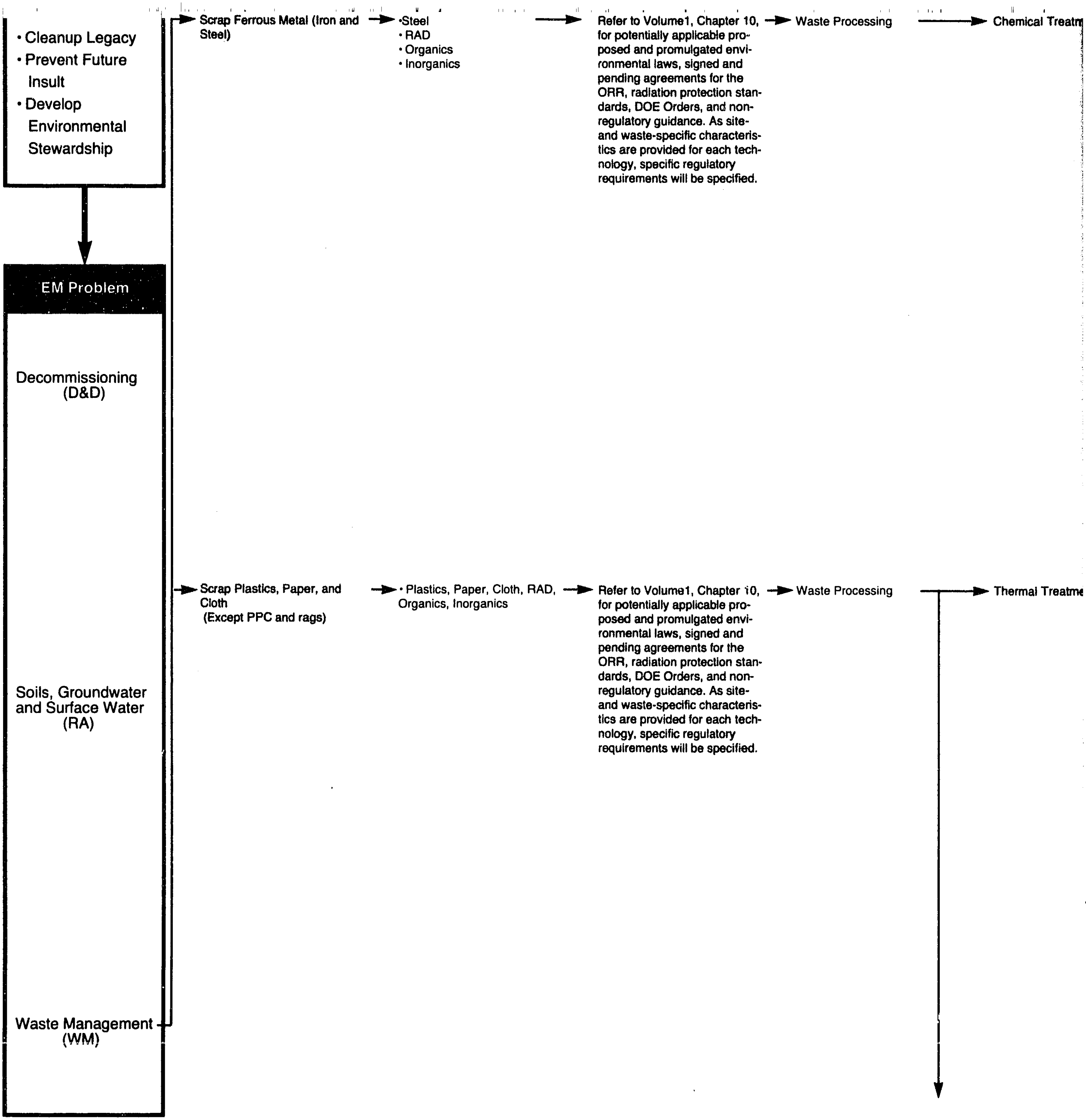
- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
Scrap, Aluminum, Copper, and Other Non-Ferrous Metals (except Nickel)	• Aluminum Non-ferrous metal • RAD • Organics • Inorganics	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Chemic
Scrap Ferrous Metal (Iron and Steel)	•Steel • RAD • POrganics • Inorganics	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Waste Therma

Chemical Treatment	Gas Phase (ClF_3) Treatment DCON-16-OG	**Pre-Demonstration** Laboratory scale studies have shown that this process can effectively remove uranium deposits at room temperature. The process should also be effective in removing other radionuclides such as technetium. However, additional RD&D is needed to demonstrate the full capabilities of the process.	Further RD&D on the process is needed to develop the optimum processing conditions. Development and demonstration of the optimum process conditions and unit operations for the removal of radioactive contaminants from the wastes and for the recycle of the reactant (ClF3).	The RD&D effort is estimated to require $ 5 million.
	Leaching & Stripping WPRO-213-OG	**Demonstration** This is an accepted technology in industry with removal efficiencies greater than 99% however, each application requires additional RD&D to determine optimum leachant composition and process conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	Demonstrate the effectiveness of the technology to meet the site requirements.
Waste Stabilization	See Waste Stabilization			
Thermal Treatment	Smelting WPRO-111-OG	**Demonstration** This is accepted industrial technology for the treatment and processing of metals. The technology has a DRE for organics greater than 99%. However, its use for the removal and separation of the radionuclides from the wastes requires additional RD&D. The process could be used for the removal of uranium from the waste but it may not be suitable for the removal of technetium. The disadvantage is that smelting may cause the surface radioactive contamination to become bulk contamination of the waste.	The use of the technology to meet the site requirements needs to be demonstrated.	The RD&D effort is estimated to require $ 3-5 million. The payback could be significant yielding a major waste minimization effort due to recovery and recycle of the metals.



• Cleanup Legacy
• Prevent Future Insult
• Develop Environmental Stewardship
EM Problem
Decommissioning (D&D)
Soils, Groundwater and Surface Water (RA)
Waste Management (WM)
Scrap Ferrous Metal (Iron and Steel)
•Steel
• RAD
• Organics
• Inorganics
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Waste Processing
Chemical Treatm
Scrap Plastics, Paper, and Cloth (Except PPC and rags)
• Plastics, Paper, Cloth, RAD, Organics, Inorganics
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Waste Processing
Thermal Treatme

Logic Diagram

Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Treatment	Solvent Extraction WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
	Leaching & Stripping WPRO-213-OG	**Demonstration** This is an accepted technology in industry with removal efficiencies greater than 99% however, each application requires additional RD&D to determine optimum leachant composition and process conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	Demonstrate the effectiveness of the technology to meet the site requirements.
Thermal Treatment	Incineration WPRO-108-OG	**Accepted** The EPA considers incineration to be the best demonstrated available technology (BDAT) for the destruction of organics. Incineration can achieve DREs greater than 99.999% for certain organics. However, additional RD&D on several aspects of incineration is still required.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated. Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	Knowledge of process application, funding, and regulatory approval. For example, the K-25 Site TSCA Incinerator is a 30 MMBtu/h unit that is permitted to destroy low-level radioactively contaminated mixed wastes. The unit was built at a capital cost of $ 26 million (1987 dollars). Obtaining regulatory approval for the TSCA Incinerator took over 8 years. The 1992 destruction costs at the incinerator are estimated to be $ 10 per pound of waste incinerated.
	Chem Char Process WPRO-114-OG	**Pre-Demonstration** This is a developmental technology based on coal char gasification. The process is claimed to achieve near total destruction of the organics and produces an inert char residue that contains the non-volatile toxic metals and radionuclides. This char residue can either be vitrified to yield a glassy slag or immobilized in cement.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.

Technology Lo
Waste Manag

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Scrap Plastics, Paper, and Cloth (Except PPC and rags)	• Plastics, Paper, Cloth, RAD, Organics, Inorganics	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Therma
EM Problem Decommissioning (D&D) Soils, Groundwater and Surface Water (RA) Waste Management (WM)	Contaminated Personal Protective Clothing (PPC) and Rags	• Cloth • RAD • Inorganics • Organics	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Waste Chemic Therma

Thermal Treatment	Molten Salt Oxidation WPRO-113-OG	**Demonstration** This is not a new process however, its application for treating hazardous and radioactive contaminants has not been demonstrated. One advantage of the process is that the process and equipment is transportable (as opposed to a fixed treatment facility) and can be located near the waste site. The process should be capable of destroying organics with a >99% efficienc. Additional RD&D is required to fully develop the process to treat mixed wastes.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.4 million for a 3 year development effort.
Waste Stabilization	See Waste Stabilization			
Chemical Treatment	Solvent Extraction WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
Thermal Treatment	Incineration WPRO-108-OG	**Accepted** The EPA considers incineration to be the best demonstrated available technology (BDAT) for the destruction of organics. Incineration can achieve DREs greater than 99.999% for certain organics. However, additional RD&D on several aspects of incineration is still required.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated, Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	Knowledge of process application, funding, and regulatory approval.

Technology Logi

Waste Managem

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alterna
Contaminated Personal Protective Clothing (PPC) and Rags	• Cloth • RAD • Inorganics • Organics	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Thermall Treatm
Waste UO_2F_2	• UO_2F_2 • Actinides • Inorganics	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Waste Stabilize Chemical Trea

Logic Diagram
Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Thermall Treatment (contd)	Molten Salt Oxidation WPRO-113-OG	**Demonstration** This is not a new process however, its application for treating hazardous and radioactive contaminants has not been demonstrated. One advantage of the process is that the process and equipment is transportable (as opposed to a fixed treatment facility) and can be located near the waste site. The process should be capable of destroying organics with a >99% efficiency. Additional RD&D is required to fully develop the process to treat mixed wastes.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.4 million for a 3 year development effort.
	Steam Stripping WPRO-221-OG	**Demonstration** This is an accepted industrial process that can remove volatile organics with >99+% efficiency especially from contaminated aqueous streams. The application of the process to satisfactorily remove hazardous and radioactive species needs to be demonstrated.	Demonstrate the effectiveness of the technology to meet the site requirements.	The RD&D effort is estimated to require $ 1-2 million to meet site specific needs.
	Chem Char Process WPRO-114-OG	**Pre-Demonstration** This is a developmental technology based on coal char gasification. The process is claimed to achieve near total destruction of the organics and produces an inert char residue that contains the non-volatile toxic metals and radionuclides. This char residue can either be vitrified to yield a glassy slag or immobilized in cement.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
Waste Stabilization	See Waste Stabilization			
Chemical Treatment	Leaching & Stripping WPRO-213-OG	**Demonstration** This is an accepted technology in industry with removal efficiencies greater than 99% however, each application requires additional RD&D to determine optimum leachant composition and process conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	Demonstrate the effectiveness of the technology to meet the site requirements.

Technology Lo

Waste Manag

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Waste UO_2F_2	• UO_2F_2 • Actinides • Inorganics	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Chemic Thermal

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

Chemical Treatment (contd)	Solvent Extraction WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
	Precipitation WPRO-210-OG	**Accepted** Precipitation technologies are fairly mature. Iron co-precipitation is presently being used at the K-25 Site Central Neutralization Facility for separating radionuclides from the aqueous wastes. However, significant development is still necessary to meet the increasingly stringent regulatory limits on the wastewater discharges. For example, precipitation using potassium ferrate has not been demonstrated and additional RD&D is required to prove its applicability and performance in treating the wastewater.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated.	The demonstration effort is estimated to require $ 0.4 million.
	Bucky Ball Chemistry WPRO-101-OG	**Evolving Technology** This is a novel technology that has many potential applications in fields such as mixed wastes treatment, nuclear medicine, tribology, and material science. Conceptually, the technology is sophisticated (uses lasers) and yet simple. For mixed wastes treatment, the process would essentially encapsulate the radioactive and hazardous metals at the elemental level in high molecular weight carbon cages (called fullerenes) thereby isolating them from the environment.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop the technology is estimated to require $ 10 million. The payback is estimated to be in the range of $ 150 million considering savings in waste treatment and disposal costs and potential spinoffs in other fields such as nuclear medicine and new materials.
Thermal Treatment	Calcination/Roasting DCON-60-OG	**Demonstration** This is accepted industrial technology for the treatment of ores. However, its use for the removal and destruction of oils and organics from the site wastes needs to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.

• Cleanup Legacy
• Prevent Future Insult
• Develop Environmental Stewardship
EM Problem
Decommissioning (D&D)
Soils, Groundwater and Surface Water (RA)
Waste Management (WM)
Waste UO_2F_2
• UO_2F_2
• Actinides
• Inorganics
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Waste Processing
Thermal Treatm
Spent Ion Exchance Media
•Ion Exchange Media
• Organics
• Inorganics
• RAD
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Waste Processing
Waste Stabiliza
Chemical Treatm

Logic Diagram
Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Thermal Treatment (contd)	Molten Glass Combustor WPRO-116-OG	**Accepted** This is accepted industrial technology for mixed wastes treatment. The process can achieve DREs greater than 99%. EPA has accepted this process as best demonstrated available technology (BDAT) for the treatment of hazardous high-level nuclear wastes. Operating costs for the process are likely to be high.	Some development work is required to apply the method to treat the site wastes.	Knowledge of process application, funding, and regulatory approval.
Waste Stabilization	See Waste Stabilization			
Chemical Treatment	Elution WPRO-104-OG	**Demonstration** This is accepted technology for the treatment of spent ion exchange media. However, the site specific applications may need to be demonstrated.	Demonstrate the effectiveness of the technology to meet the site requirements.	This technology has no unique implementation needs.
	Leaching & Stripping WPRO-213-OG	**Demonstration** This is an accepted technology in industry with removal efficiencies greater than 99% however, each application requires additional RD&D to determine optimum leachant composition and process conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	Demonstrate the effectiveness of the technology to meet the site requirements.
	Supercritical Water Oxidation WPRO-216-OG	**Demonstration**	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment. Significant development is needed to solve the problems of corrosion, plugging, and caking of the reactors. Overall experience is also needed on the specific problems that may be associated with the processing of particular types of wastes. This information could be used to develop a technology database to support the applicability and relative merits of this promising technology.	The RD&D effort is estimated to require $ 1.6 million for a 3 year development plan.

Technology Lo

Waste Manag

EM Goals

- Cleanup Legacy
- Prevent Future Insuit
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

Spent Ion Exchange Media

Problem Area/Constituents

- Ion Exchange
- Organics
- Inorganics
- RAD

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelements

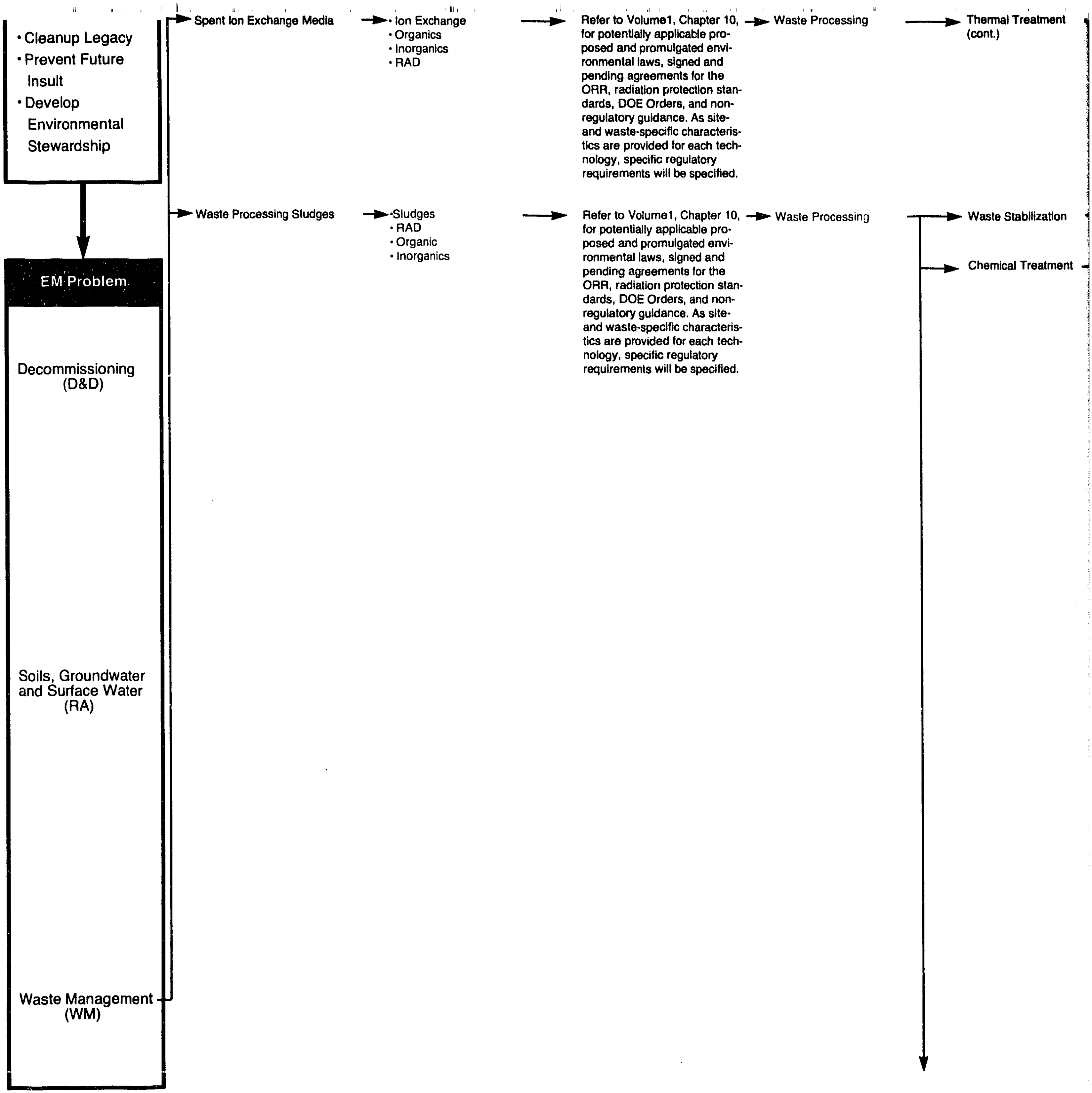
Waste Processing

A

Thermal

ogic Diagram
nagement

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Thermal Treatment	Incineration WPRO-108-OG	**Accepted** The feasibility of the process has been proven at the bench-scale. If proven effective at the industrial -scale, the process could treat and dispose of all the contaminated aluminum from D&D operations. This aluminum would be used in the process to treat the radioactively contaminated nitrate wastes in the Hanford site tanks. This process would thus help treat and dispose of two major DOE wastes.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated, Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	Knowledge of process application, funding, and regulatory approval. For example, the K-25 Site TSCA Incinerator is a 30 MMBtu/h unit that is permitted to destroy low-level radioactively contaminated mixed wastes. The unit was built at a capital cost of $ 26 million (1987 dollars). Obtaining regulatory approval for the TSCA Incinerator took over 8 years. The 1992 destruction costs at the incinerator are estimated to be $ 10 per pound of waste incinerated.
	Molten Salt Oxidation WPRO-113-OG	**Demonstration** This is not a new process however, its application for treating hazardous and radioactive contaminants has not been demonstrated. One advantage of the process is that the process and equipment is transportable (as opposed to a fixed treatment facility) and can be located near the waste site. The process should be capable of destroying organics with a >99% efficiency. Additional RD&D is required to fully develop the process to treat mixed wastes.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.4 million for a 3 year development effort.
	Calcination/Roasting DCON-60-OG	**Demonstration** This is accepted industrial technology for the treatment of ores. However, its use for the removal and destruction of oils and organics from the site wastes needs to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.
	Molten Glass Combustor WPRO-116-OG	**Demonstration** This is accepted industrial technology for mixed wastes treatment. The process can achieve DREs greater than 99%. EPA has accepted this process as best demonstrated available technology (BDAT) for the treatment of hazardous high-level nuclear wastes. Operating costs for the process are likely to be high.	Some development work is required to apply the method to treat the site wastes.	Knowledge of process application, funding, and regulatory approval.
	Catalytic Destruction WPRO-109-OG	Pre-Demonstration This technology has been demonstrated to be effective (DRE>99+%) for the destruction of liquid and gaseous organic wastes. However, its use to remove and destroy the organics from solids needs additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.


• Cleanup Legacy
• Prevent Future Insult
• Develop Environmental Stewardship
EM Problem
Decommissioning (D&D)
Soils, Groundwater and Surface Water (RA)
Waste Management (WM)
Spent Ion Exchange Media
• Ion Exchange
• Organics
• Inorganics
• RAD
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Waste Processing
Thermal Treatment (cont.)
Waste Processing Sludges
•Sludges
• RAD
• Organic
• Inorganics
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Waste Processing
Waste Stabilization
Chemical Treatment

Thermal Treatment (cont.)	Chem Char Process WPRO-114-OG	**Pre-Demonstraton** This is a developmental technology based on coal char gasification. The process is claimed to achieve near total destruction of the organics and produces an inert char residue that contains the non-volatile toxic metals and radionuclides. This char residue can either be vitrified to yield a glassy slag or immobilized in cement.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
Waste Stabilization	See Waste Stabilization			
Chemical Treatment	Solvent Extraction WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
	Leaching & Stripping WPRO-213-OG	**Demonstration** This is an accepted technology in industry with removal efficiencies greater than 99% however, each application requires additional RD&D to determine optimum leachant composition and process conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	Demonstrate the effectiveness of the technology to meet the site requirements.
	Incineration WPRO-108-OG	**Accepted** The EPA considers incineration to be the best demonstrated available technology (BDAT) for the destruction of organics. Incineration can achieve DREs greater than 99.999% for certain organics. However, additional RD&D on several aspects of incineration is still required.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated, Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	Knowledge of process application, funding, and regulatory approval. For example, the K-25 Site TSCA Incinerator is a 30 MMBtu/h unit that is permitted to destroy low-level radioactively contaminated mixed wastes. The unit was built at a capital cost of $ 26 million (1987 dollars). Obtaining regulatory approval for the TSCA Incinerator took over 8 years. The 1992 destruction costs at the incinerator are estimated to be $ 10 per pound of waste incinerated.

Technology Lo

Waste Manag

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

Waste Processing Sludges

Problem Area/Constituents

- Sludges
- RAD
- Organic
- Inorganics

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelements

Waste Processing

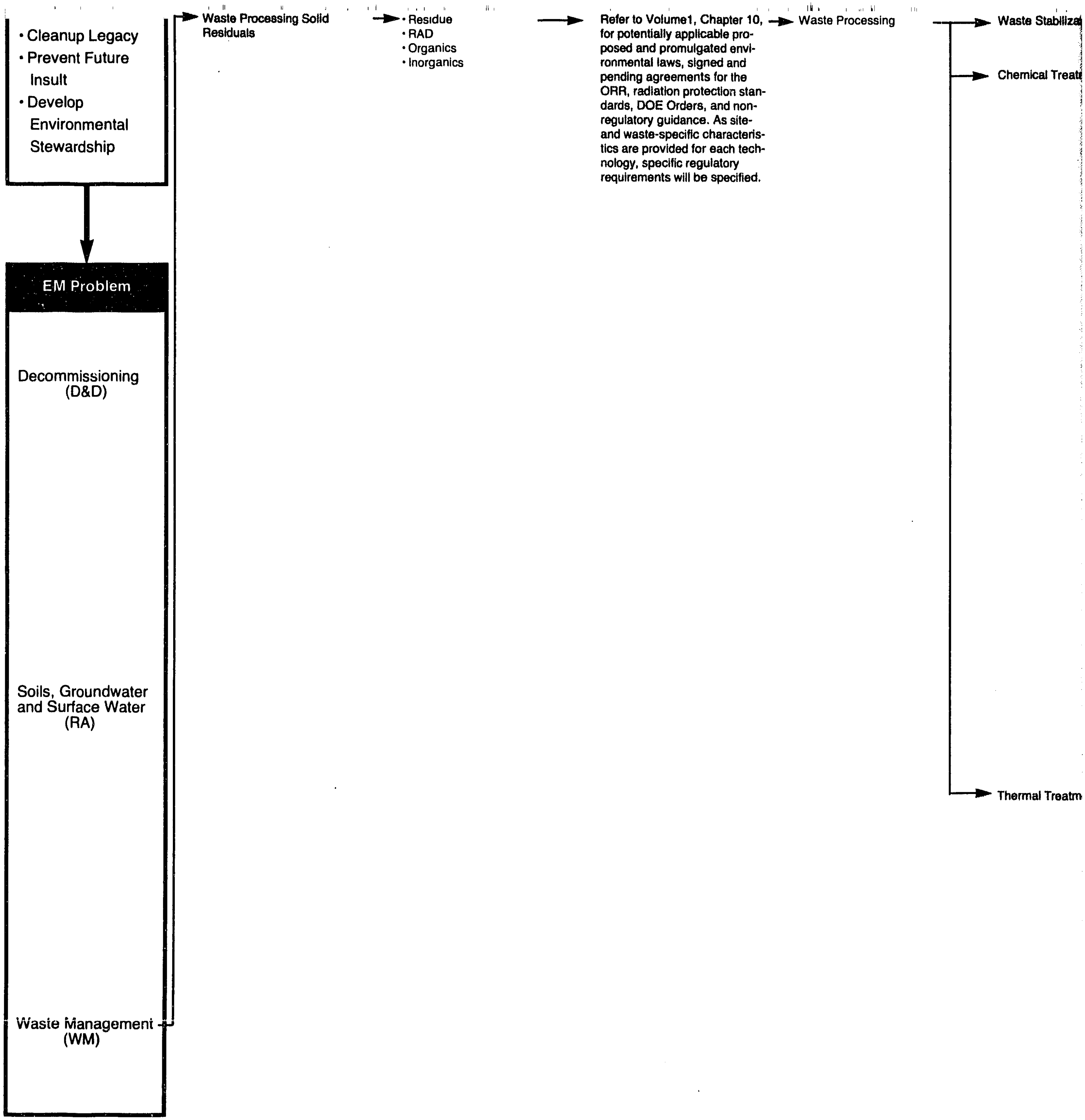
A

Chemic

Thermal

Biotreatm

Chemical Treatment (contd)	Catalytic Destruction WPRO-109-OG	**Pre-Demonstration** This technology has been demonstrated to be effective (DRE>99+%) for the destruction of liquid and gaseous organic wastes. However, its use to remove and destroy the organics from solids needs additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
Thermal Treatment	Calcination/Roasting DCON-60-OG	**Demonstration** This is accepted industrial technology for the treatment of ores. However, its use for the removal and destruction of oils and organics from the site wastes needs to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.
	Chem Char Process WPRO-114-OG	**Pre-Demonstration** This is a developmental technology based on coal char gasification. The process is claimed to achieve near total destruction of the organics and produces an inert char residue that contains the non-volatile toxic metals and radionuclides. This char residue can either be vitrified to yield a glassy slag or immobilized in cement.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
	Wet Air Oxidation WPRO-215-OG	**Demonstration** The process is commercially available. It is capable of greater than 99+% destruction of some organics however, it may not be able to completely destroy certain refractory organics such as halogenated aromatics (e.g., PCB). Processing costs are likely to be high.	Demonstrate the effectiveness of the technology to meet the site requirements.	The development effort is estimated to require approximately $ 1 million.
	Microwave Heating WPRO-115-OG	**Demonstration** This is a novel technology for the thermal treatment of radioactive wastes. The technology is at the laboratory scale of development.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 2.5 million.
	Molten Glass Combustor WPRO-116-OG	**Accepted** This is accepted industrial technology for mixed wastes treatment. The process can achieve DREs greater than 99%. EPA has accepted this process as best demonstrated available technology (BDAT) for the treatment of hazardous high-level nuclear wastes. Operating costs for the process are likely to be high.	Some development work is required to apply the method to treat the site wastes.	Knowledge of process application, funding, and regulatory approval.
Biotreatment	Biodegradation WPRO-117-OG	**Evolving Technology** This is a promising technology for hazardous waste treatment. The process can achieve impressive treatment efficiencies for certain organics. However, the process is slow and may not be able to completely destroy certain refractory organics.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-10 million. The payback could be significant.


• Cleanup Legacy
• Prevent Future Insult
• Develop Environmental Stewardship
EM Problem
Decommissioning (D&D)
Soils, Groundwater and Surface Water (RA)
Waste Management (WM)
Waste Processing Solid Residuals
• Residue
• RAD
• Organics
• Inorganics
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Waste Processing
Waste Stabiliza
Chemical Treat
Thermal Treatm

Waste Stabilization	See Waste Stabilization			
Chemical Treatment	Leaching & Stripping WPRO-213-OG	**Demonstration** This is an accepted technology in industry with removal efficiencies greater than 99% however, each application requires additional RD&D to determine optimum leachant composition and process conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	Demonstrate the effectiveness of the technology to meet the site requirements.
	Solvent Extraction WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
	Transmutation WPRO-219-OG	**Conceptual** The future of an industrial scale transmutation facility is highly dependent on the availability of a permanent high level waste repository. A "national" transmutation facility would greatly facilitate the destruction and disposal of "problem" radionuclides such as technetium.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	An industrial-scale national transmutation facility would need to be developed and built. The cost for such a "national" facility is estimated to be in the billion dollars ran[illegible] would require severa[illegible] [illegible]d.
Thermal Treatment	Incineration WPRO-108-OG	**Accepted** The EPA considers incineration to be the best demonstrated available technology (BDAT) for the destruction of organics. Incineration can achieve DREs greater than 99.999% for certain organics. However, additional RD&D on several aspects of incineration is still required.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated, Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	Knowledge of process application, funding, and regulatory approval.
	Roasting/Calcination DCON-60-OG	**Demonstration** This is accepted industrial technology for the treatment of ores. However, its use for the removal and destruction of oils and organics from the site wastes needs to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.

Technology Lo

Waste Manag

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Waste Processing Solid Residuals	• Residue • RAD • Organics • Inorganics	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Thermal

EM Problem

Decommissioning (D&D)

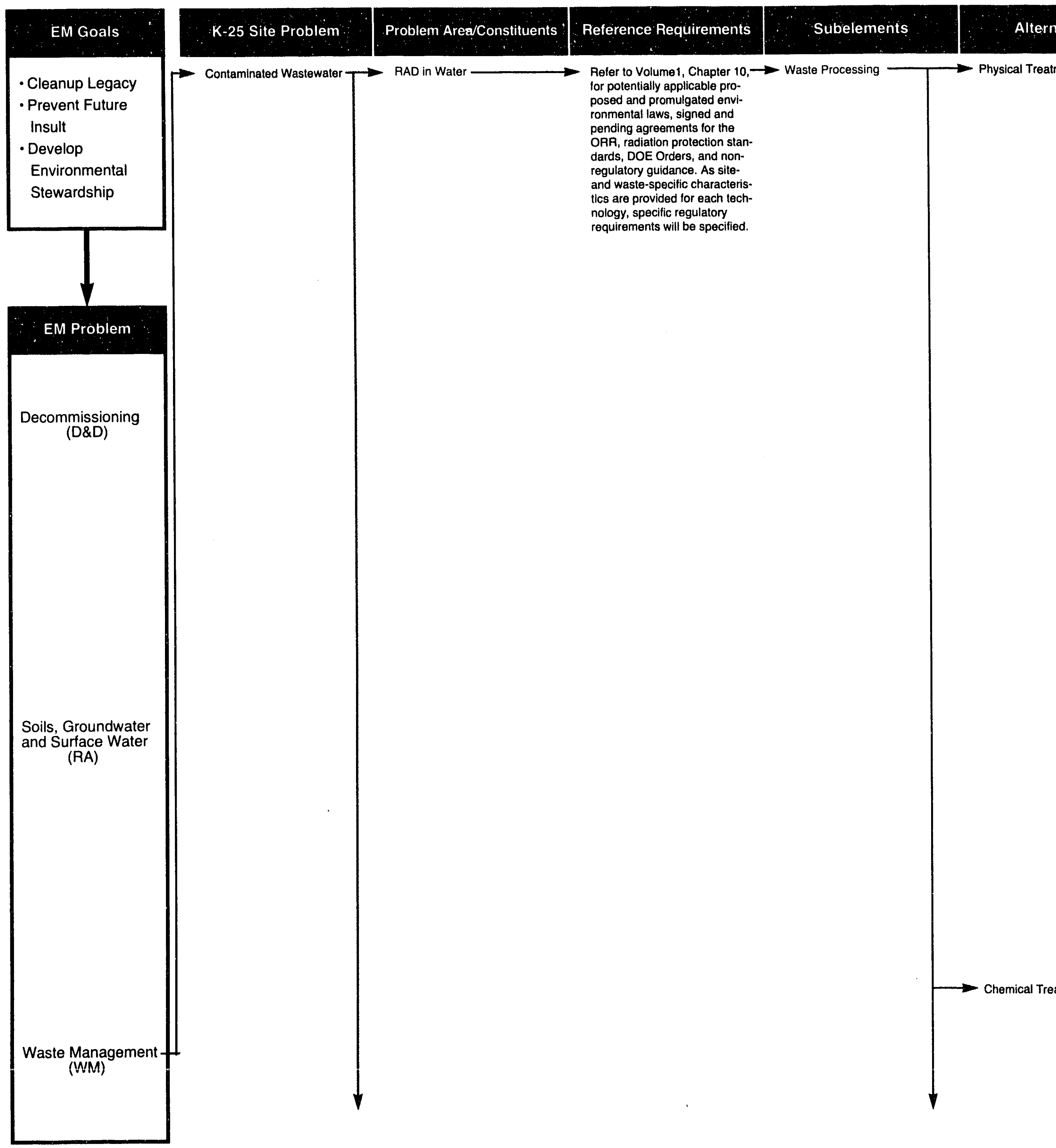
Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

Category	Technology	Status	Need	Estimated Effort
Thermal Treatment	Molten Salt Oxidation WPRO-113-OG	**Demonstration** This is not a new process however, its application for treating hazardous and radioactive contaminants has not been demonstrated. One advantage of the process is that the process and equipment is transportable (as opposed to a fixed treatment facility) and can be located near the waste site. The process should be capable of destroying organics with a >99% efficiency. Additional RD&D is required to fully develop the process to treat mixed wastes.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.4 million for a 3 year development effort.
	Wet Air Oxidation WPRO-215-OG	**Demonstration** The process is commercially available. It is capable of greater than 99+% destruction of some organics however, it may not be able to completely destroy certain refractory organics such as halogenated aromatics (e.g., PCB). Processing costs are likely to be high.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The development effort is estimated to require approximately $ 1 million.
	Chem Char Process WPRO-114-OG	**Pre-Demonstration** This is a developmental technology based on coal char gasification. The process is claimed to achieve near total destruction of the organics and produces an inert char residue that contains the non-volatile toxic metals and radionuclides. This char residue can either be vitrified to yield a glassy slag or immobilized in cement.	Further research, development, and demonstration (PD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
	Microwave Heating WPRO-115-OG	**Demonstration** This is a novel technology for the thermal treatment of radioactive wastes. The technology is at the laboratory scale of development.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 2.5 million.
	Molten Glass Combustor WPRO-116-OG	**Accepted** This is accepted industrial technology for mixed wastes treatment. The process can achieve DREs greater than 99%. EPA has accepted this process as best demonstrated available technology (BDAT) for the treatment of hazardous high-level nuclear wastes. Operating costs for the process are likely to be high.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-10 million. The payback could be significant.

Technology Logi

Waste Managem



-ogic Diagram
anagement

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Treatment	Adsorption WPRO-202/203-OG	**Pre-Demonstration** Laboratory studies indicate removal efficiencies greater than 90% for the removal of radioactive species using various adsorbing media. Further development is necessary to develop more effective adsorption media for the treatment of mixed waste contaminated liquids. Development would include for example, scale-up studies, development of high surface area and appropriate particle size media for continuous operations, and the development of appropriate media for the removal of various contaminants.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
	Electrolysis WPRO-205-OG	**Demonstration** The basic technology is well established in industry however, its application to meet the site requirements needs to be developed and demonstrated. Removal efficiencies for the process are in general greater than 90%.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
	Reverse Osmosis WPRO-206-OG	**Demonstration** Reverse osmosis is commercial technology for treating aqueous streams. When properly designed and operated the technology is capable of greater than 99% rejection of the salts. However, additional RD&D may be required to develop membranes that meet the site specific requirements.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop applicable membranes is estimated to require $ 0.75 million.
	Ultrafiltration WPRO-206-OG	**Demonstration** Ultrafiltration is also a membrane separation process that is similar to reverse osmosis. However, it will not remove low to intermediate molecular weight solutes from the liquid stream.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop applicable membranes is estimated to require $ 0.75 million.
	Inorganic Microporous Filters WPRO-207	**Pre-Demonstration** This is novel technology being developed for filtration applications. Some of the advantages of these filters are that they can be used in severe environments, they can be readily cleaned if they get fouled, and they can be re-used indefinitely. Their separation efficiency can be 99%+.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.
Chemical Treatment	Chemical Fixation WPRO-208	**Demonstration** This process consists of fixing the contaminants by chemical reaction so that they can be removed by filtration or other separation techniques. The process should be capable of 90%+ treatment efficiencies.	Demonstrate the effectiveness of the technology to meet the site requirements.	The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.

Technology Lo

Waste Manag

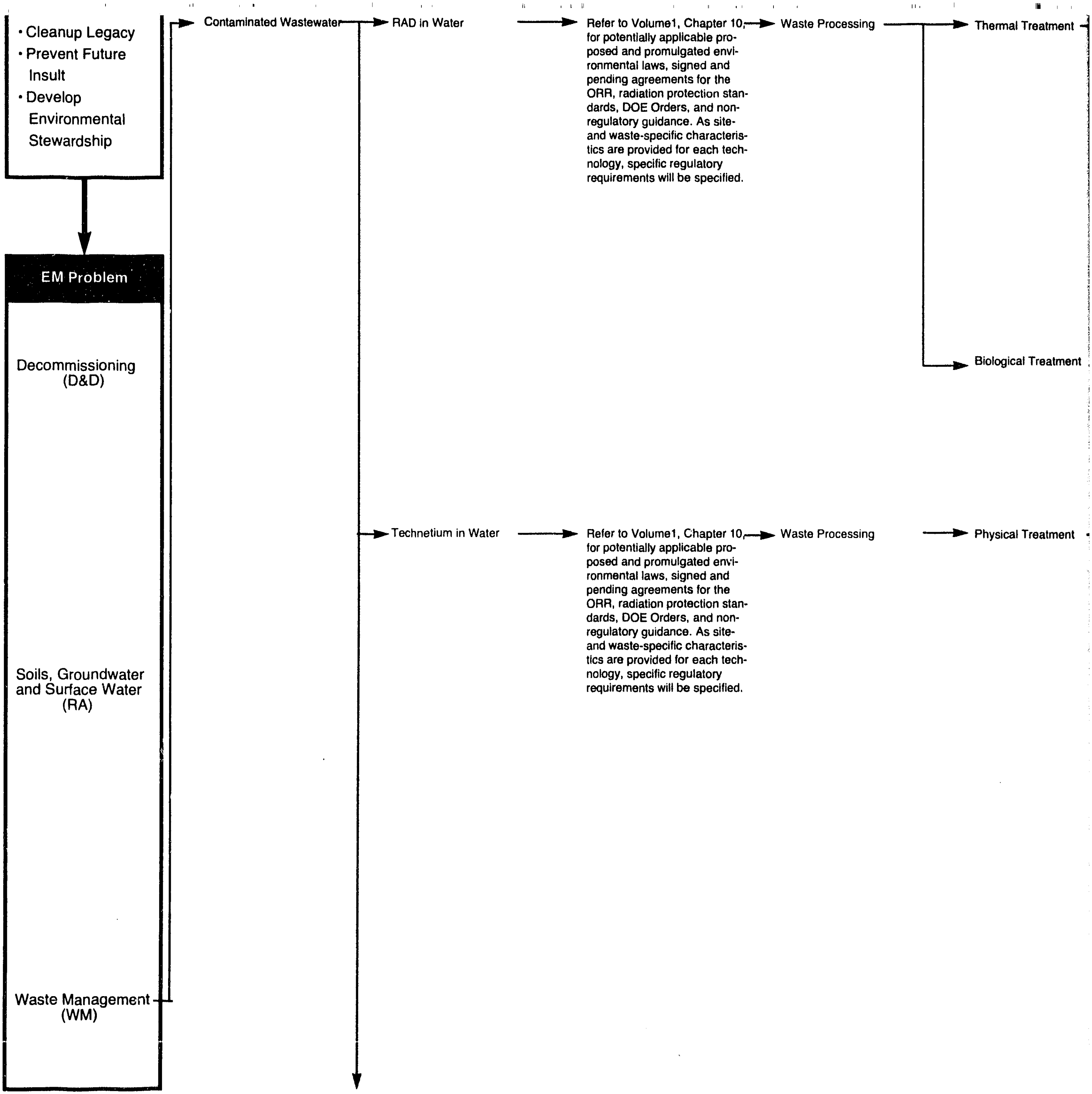
EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Wastewater	RAD in Water	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Chemic

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Chemical Treatment

Technology	Status	Needs	Cost
Chemical Reduction WPRO-209-OG	**Pre-Demonstration** This process consists of chemically reacting the contaminants with appropriate reagents to alter the chemical state of the contaminants to make them easier to remove from the fluid. Treatment efficiencies should generally be greater than 95%.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25-2.5 million.
Chemical Precipitation WPRO-.210-OG	**Demonstration** Precipitation technologies are fairly mature. Iron co-precipitation is presently being used at the K-25 Site Central Neutralization Facility for separating radionuclides from the aqueous wastes. However, significant development is still necessary to meet the increasingly stringent regulatory limits on the wastewater discharges. For example, precipitation using potassium ferrate has not been demonstrated and additional RD&D is required to prove its applicability and performance in treating the wastewater.	Demonstrate the effectiveness of the technology to meet the site requirements.	The demonstration effort is estimated to require $ 0.4 million.
Solvent Extraction WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
Ion Exchange WPRO-217/218-OG	**Demonstration** This is one of the accepted methods used in industry for treating liquids. Treatment efficiencies can be greater than 99% depending upon the application, the ion exchange media, and the solutes to be removed.	The use of the technology to meet the site requirements needs to be demonstrated.	Development costs are estimated to be $ 1.25 million.



• Cleanup Legacy
• Prevent Future Insult
• Develop Environmental Stewardship
EM Problem
Decommissioning (D&D)
Soils, Groundwater and Surface Water (RA)
Waste Management (WM)
Contaminated Wastewater
RAD in Water
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Waste Processing
Thermal Treatment
Biological Treatment
Technetium in Water
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Waste Processing
Physical Treatment

Thermal Treatment	Distillation WPRO-222-OG	**Demonstration** This is an accepted industrial process for treating liquids. Depending upon the contaminant being removed, the separation efficiency can be greater than 99%. However, the use of the process to meet site requirements will need to be demonstrated. Capital and operating costs could be high.	The use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
	Evaporation WPRO-223-OG	**Demonstration** This is similar to distillation and is an accepted industrial process for treating contaminated liquids. It is usually used when the solvent is of low value and can be disposed. Like distillation, the operating costs can be high for certain applications.	The use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
Biological Treatment	Biosorption WPRO-226-OG	**Pre-Demonstration** Data in the scientific literature suggests that given the right conditions, this process should be able to achieve impressive (>95%) treatment efficiencies however, most of the information is based on laboratory-scale data. There is little pilot plant or industrial scale data on the process.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-3 million.
Physical Treatment	Reverse Osmosis WPRO-206-OG	**Demonstration** Reverse osmosis is commercial technology for treating aqueous streams. When properly designed and operated the technology is capable of greater than 99% rejection of the salts. However, additional RD&D may be required to develop membranes that meet the site specific requirements.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop applicable membranes is estimated to require $ 0.75 million.
	Ultrafiltration WPRO-.206-OG	**Pre-Demonstration** Ultrafiltration is also a membrane separation process that is similar to reverse osmosis. However, it will not remove low to intermediate molecular weight solutes from the liquid stream.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop applicable membranes is estimated to require $ 0.75 million.
	High Gradiant Magnetic Separation (HGMS) WPRO-204-OG	**Pre-Demonstration** The treatment is commercially available for example, for the removal of trace impurities from kaolin clays. Removal efficiencies for the process are greater than 99%. However, its use to treat mixed waste contaminated fluids needs additional RD&D.	The use of the technology to meet the site requirements needs to be demonstrated.	• High Gradiant Magnetic Separation (HGMS)

Technology Lo

Waste Manag

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Wastewater (cont.)	Technetium in Water	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physica (cont.) Chemic

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Physical Treatment (cont.)	Electrodialysis WPRO-206-OG	**Pre-Demonstration** Electrodialysis is a variation of a membrane separation process that has been tried for the removal of radionuclides from water. The removal efficiency for radionuclides is generally in the 90+% range.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.
	Inorganic Microporous Filters WPRO-207-OG	**Pre-Demonstration** This is novel technology being developed for filtration applications. Some of the advantages of these filters are that they can be used in severe environments, they can be readily cleaned if they get fouled, and they can be re-used indefinitely. Their separation efficiency can be 99%+.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.
	Adsorption WPRO-202/203-OG	**Demonstration** Laboratory studies indicate removal efficiencies greater than 90% for the removal of radioactive species using various adsorbing media. Further development is necessary to develop more effective adsorption media for the treatment of mixed waste contaminated liquids. Development would include for example, scale-up studies, development of high surface area and appropriate particle size media for continuous operations, and the development of appropriate media for the removal of various contaminants.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
Chemical Treatment	Ion Exchange WPRO-217/218-OG	**Demonstration** This is one of the accepted methods used in industry for treating liquids. Treatment efficiencies can be greater than 99% depending upon the application, the ion exchange media, and the solutes to be removed.	The use of the technology to meet the site requirements needs to be demonstrated.	Development costs are estimated to be $ 1.25 million.
	Chemical Precipitation WPRO-210-OG	**Demonstration** Precipitation technologies are fairly mature. Iron co-precipitation is presently being used at the K-25 Site Central Neutralization Facility for separating radionuclides from the aqueous wastes. However, significant development is still necessary to meet the increasingly stringent regulatory limits on the wastewater discharges. For example, precipitation using potassium ferrate has not been demonstrated and additional RD&D is required to prove its applicability and performance in treating the wastewater.	Demonstrate the effectiveness of the technology to meet the site requirements.	The demonstration effort is estimated to require $ 0.4 million.

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

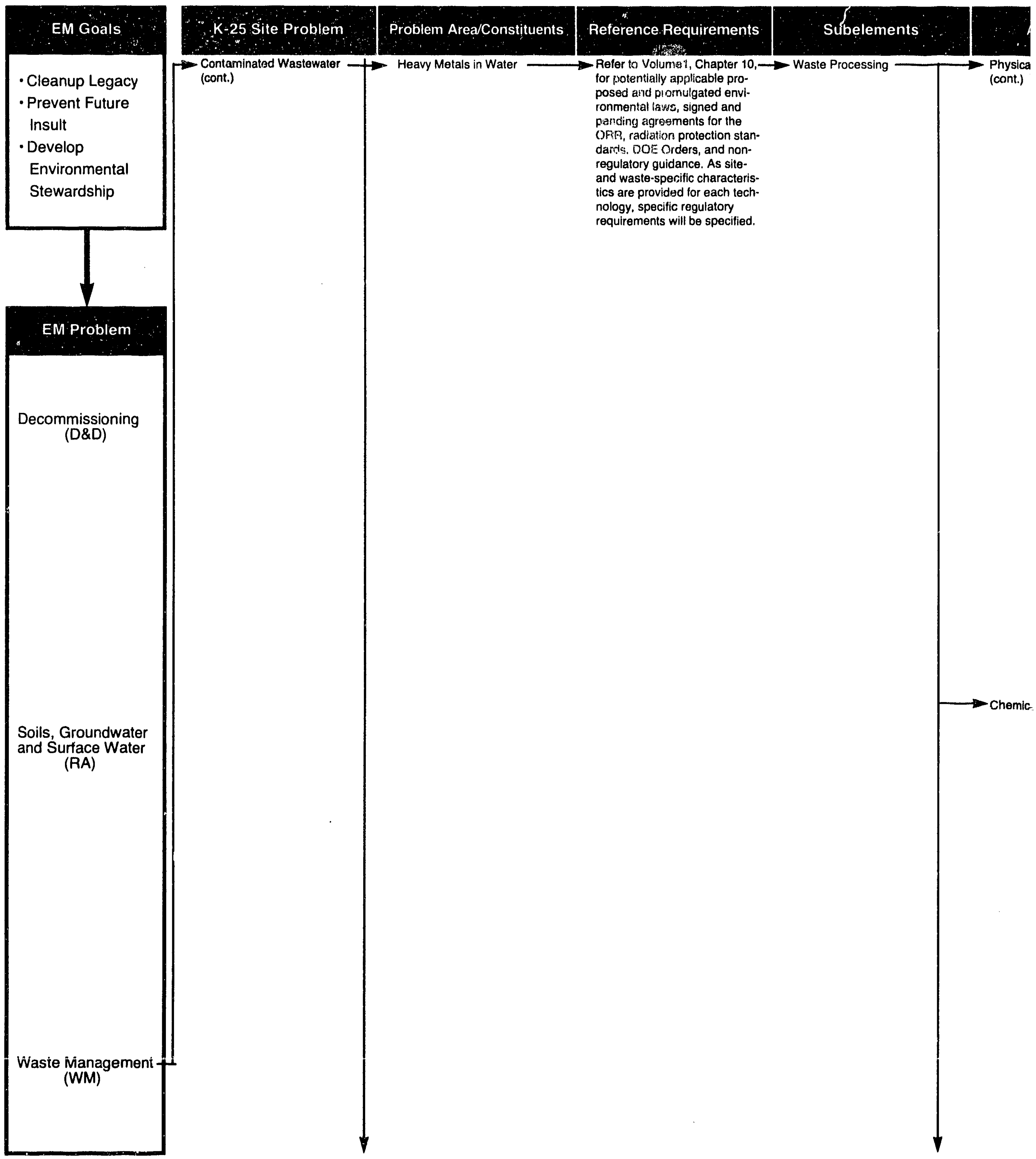
Waste Management (WM) → Contaminated Wastewater → Technetium in Water → Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified. → Waste Processing → Chemica

Contaminated Wastewater → Heavy Metals in Water → Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified. → Waste Processing → Physical

Chemical Treatment	Chemical Fixation WPRO-208-OG	**Demonstration** This process consists of fixing the contaminants by chemical reaction so that they can be removed by filtration or other separation techniques. The process should be capable of 90%+ treatment efficiencies.	Demonstrate the effectiveness of the technology to meet the site requirements.	The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.
	Solvent Extraction WPRO-211/212-OG	**Pre-Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
Physical Treatment	Adsorption WPRO-202/203-OG	**Pre-Demonstration** Laboratory studies indicate removal efficiencies greater than 90% for the removal of radioactive species using various adsorbing media. Further development is necessary to develop more effective adsorption media for the treatment of mixed waste contaminated liquids. Development would include for example, scale-up studies, development of high surface area and appropriate particle size media for continuous operations, and the development of appropriate media for the removal of various contaminants.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
	Electrolysis WPRO-205-OG	**Demonstration** The basic technology is well established in industry however, its application to meet the site requirements needs to be developed and demonstrated. Removal efficiencies for the process are in general greater than 90%.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.

Technology Lo

Waste Manag



Physical Treatment (cont.)	Reverse Osmosis WPRO-206-OG	**Demonstration** Reverse osmosis is commercial technology for treating aqueous streams. When properly designed and operated the technology is capable of greater than 99% rejection of the salts. However, additional RD&D may be required to develop membranes that meet the site specific requirements.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop applicable membranes is estimated to require $ 0.75 million.
	Ultrafiltration WPRO-206-OG	**Demonstration** Ultrafiltration is also a membrane separation process that is similar to reverse osmosis. However, it will not remove low to intermediate molecular weight solutes from the liquid stream.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop applicable membranes is estimated to require $ 0.75 million.
	Inorganic Microporous Filters WPRO-207-OG	**Pre-Demonstration** This is novel technology being developed for filtration applications. Some of the advantages of these filters are that they can be used in severe environments, they can be readily cleaned if they get fouled, and they can be re-used indefinitely. Their separation efficiency can be 99%+.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.
	HGMS WPRO-204-OG	**Pre-Demonstration** The treatment is commercially available for example, for the removal of trace impurities from kaolin clays. Removal efficiencies for the process are greater than 99%. However, its use to treat mixed waste contaminated fluids needs additional RD&D.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to be $ 0.5-1 million.
Chemical Treatment	Chemical Fixation WPRO-208-OG	**Pre-Demonstration** This process consists of fixing the contaminants by chemical reaction so that they can be removed by filtration or other separation techniques. The process should be capable of 90%+ treatment efficiencies.	Demonstrate the effectiveness of the technology to meet the site requirements.	The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.
	Chemical Reduction WPRO 209-OG	**Demonstration** This process consists of chemically reacting the contaminants with appropriate reagents to alter the chemical state of the contaminants to make them easier to remove from the fluid. Treatment efficiencies should generally be greater than 95%.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25-2.5 million.

Technology Logi
Waste Managem

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Altern
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Wastewater	Heavy Metals in Water	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Chemical Treat (cont.) ThermalT.eatm

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Treatment (cont.)	Chemical Precipitation WPRO-205-OG	**Demonstration** Precipitation technologies are fairly mature. Iron co-precipitation is presently being used at the K-25 Site Central Neutralization Facility for separating radionuclides from the aqueous wastes. However, significant development is still necessary to meet the increasingly stringent regulatory limits on the wastewater discharges. For example, precipitation using potassium ferrate has not been demonstrated and additional RD&D is required to prove its applicability and performance in treating the wastewater.	Demonstrate the effectiveness of the technology to meet the site requirements.	The demonstration effort is estimated to require $ 0.4 million.
	Solvent Extraction WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
	Ion Exchange WPRO-217/218-OG	**Demonstration** This is one of the accepted methods used in industry for treating liquids. Treatment efficiencies can be greater than 99% depending upon the application, the ion exchange media, and the solutes to be removed.	The use of the technology to meet the site requirements needs to be demonstrated.	Development costs are estimated to be $ 1.25 million.
ThermalTreatment	Evaporation WPRO-223-OG	**Demonstration** This is similar to distillation and is an accepted industrial process for treating contaminated liquids. It is usually used when the solvent is of low value and can be disposed. Like distillation, the operating costs can be high for certain applications.	The use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.

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EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

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Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
Contaminated Wastewater →	PCBs in Water →	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified. →	Waste Processing →	Physica
				Chemic

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Treatment	Foaming WPRO-201-OG	**Demonstration** This process is used to recover particulates from liquids (e.g., aqueous streams). Removal efficiencies are generally greater than 90%. The process is a variation of filtration in which chemicals are added to the liquid to create a foam. The foam traps the particulates. The foam is then processed elsewhere to recover the particulates.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Sedimentation WPRO-201-OG	**Demonstration** Sedimentation is also a variation of filtration in which gravity forces are used to remove the particulates from the fluid. Removal efficiencies should generally be greater than 90%.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Adsorption WPRO-202/203-OG	**Demonstration** Laboratory studies indicate removal efficiencies greater than 90% for the removal of radioactive species using various adsorbing media. Further development is necessary to develop more effective adsorption media for the treatment of mixed waste contaminated liquids. Development would include for example, scale-up studies, development of high surface area and appropriate particle size media for continuous operations, and the development of appropriate media for the removal of various contaminants.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
	Inorganic Microporous Filters WPRO-207-OG	**Demonstration** This is novel technology being developed for filtration applications. Some of the advantages of these filters are that they can be used in severe environments, they can be readily cleaned if they get fouled, and they can be re-used indefinitely. Their separation efficiency can be 99%+.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.
Chemical Treatment	Chemical Dechlorination WPRO-209-OG	**Demonstration** This process consists of chemically reacting the contaminants with appropriate reagents to alter the chemical state of the contaminants to make them easier to remove from the fluid. Treatment efficiencies should generally be greater than 95%.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25-2.5 million.

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternati
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Wastewater	PCBs in Water	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Chemical Treatmen (cont.) Thermal Treatment

EM Problem

- Decommissioning (D&D)
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- Waste Management (WM)

→ Chemical Treatment (cont.)	→ Solvent Extraction WPRO-211/212-OG	→ **Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	→ Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	→ The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
	→ • Gamma-Radiolysis (WPRO-100-OG)	→ **Evoloving Technology** The radiolytic destruction of halogenated and aromatic compounds at the laboratory scale is well documented. However, its application on an industrial scale needs additional RD&D. The process is capable of high (>90%) destruction efficiencies for organics.	→ Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment. Some of the issues to be resolved are the complete characterization of the radiolytic decomposition products under different conditions and for different waste materials and their relative toxicity. Another issue is the possibility of combining the radiolysis with enhanced biodegradation of the radiolytic by products.	→ The RD&D effort is estimated to require $ 1.25-2.5 million.
	→ • Wet Air Oxidation (WPRO-215-OG)	→ **Pre-Demonstration** The process is commercially available. It is capable of greater than 99+% destruction of some organics however, it may not be able to completely destroy certain refractory organics such as halogenated aromatics (e.g., PCB). Processing costs are likely to be high.	→ Demonstrate the effectiveness of the technology to meet the site requirements.	→ The development effort is estimated to require approximately $ 1 million.
→ Thermal Treatment	→ Incineration WPRO-108-OG	→ **Accepted** The EPA considers incineration to be the best demonstrated available technology (BDAT) for the destruction of organics. Incineration can achieve DREs greater than 99.999% for certain organics. However, additional RD&D on several aspects of incineration is still required.	→ Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated, Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	→ Knowledge of process application, funding, and regulatory approval. For example, the K-25 Site TSCA Incinerator is a 30 MMBtu/h unit that is permitted to destroy low-level radioactively contaminated mixed wastes. The unit was built at a capital cost of $ 26 million (1987 dollars). Obtaining regulatory approval for the TSCA Incinerator took over 8 years. The 1992 destruction costs at the incinerator are estimated to be $ 10 per pound of waste incinerated.

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Wastewater	PCBs in Water	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Thermal (cont.)
					Biologica
		Volatile Organic Compounds in Water	Refer to Volume1, Chapter 10, for potentially applicable o-posed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physical

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Thermal Treatment (cont.)	Distillation WPRO-222-OG	**Demonstration** This is an accepted industrial process for treating liquids. Depending upon the contaminant being removed, the separation efficiency can be greater than 99%. However, the use of the process to meet site requirements will need to be demonstrated. Capital and operating costs could be high.	The use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
	Catalytic Destruction WPRO-109-OG	**Demonstration** This technology has been demonstrated to be effective (DRE>99+%) for the destruction of liquid and gaseous organic wastes. However, its use to remove and destroy the organics from solids needs additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
Biological Treatment	Aerobic Digestion WPRO-224-OG	**Pre-Demonstration** This is a promising technology for destroying hazardous organics. Under the right conditions, this process should be able to achieve greater than 99% destruction of the organics. Additional RD&D is needed to determine the applicability of the process to meet the site requirements.	The use of the technology to meet the site requirements needs to be demonstrated.	The RD&D effort is estimated to require $ 1-2 million to meet site specific needs.
	Anaerobic Digestion WPRO-225-OG	**Pre-Demonstration** This is a promising technology for destroying hazardous organics. Under the right conditions, this process should be able to achieve greater than 99% destruction of the organics. Additional RD&D is needed to determine the applicability of the process to meet the site requirements.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.5-2 million to further develop the process to meet the site needs.
	Microbial Dechlorination WPRO-227-OG	**Pre-Demonstration** This process is at an early stage of development. Based on the available information, it appears the process should be able to achieve destruction efficiencies greater than 90%.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 5-10 million. The payback could be significant.
Physical Treatment	Air Sparging WPRO-200-OG	**Accepted** This is an acceptable industrial process with removal efficiencies in the 90+%	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated.	The implementation needs will be determined by the site requirements.

Technology Log

Waste Manage

EM Goals	K-25 Site Problem.	Problem Area/Constituents	Reference Requirements	Subelements	Alt
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Wastewater	Volatile Organic Compounds in Water	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physical Tr (cont.) Chemical T

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Waste Management (WM)

Logic Diagram
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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Treatment (cont.)	Adsorption WPRO-202/203-OG	**Demonstration** Laboratory studies indicate removal efficiencies greater than 90% for the removal of radioactive species using various adsorbing media. Further development is necessary to develop more effective adsorption media for the treatment of mixed waste contaminated liquids. Development would include for example, scale-up studies, development of high surface area and appropriate particle size media for continuous operations, and the development of appropriate media for the removal of various contaminants.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
Chemical Treatment	Solvent Extraction WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
	Stripping WPRO-213-OG	**Demonstration** This is an accepted technology in industry with removal efficiencies greater than 99% however, each application requires additional RD&D to determine optimum leachant composition and process conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	Demonstrate the effectiveness of the technology to meet the site requirements.

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Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
Contaminated Wastewater	Volatile Organic Compounds in Water	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific charac is-tics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Chemica (cont.)
				Thermal

Logic Diagram
Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Treatment (cont.)	Ozonation-Photolysis WPRO-.214-OG	**Demonstration** This process can be very useful in destroying organics (especially refractory organics) in water. DREs for the process can be greater than 90+%. Even though some organics are easily destroyed by the process, they are rarely completely oxidized and may be converted to other hazardous species. To be successful, a thorough knowledge of the waste to be treated is essential. The process is comparatively expensive for the treatment of organics.	The use of the technology to meet the site requirements needs to be demonstrated.	The RD&D effort is estimated to require $ 1-2 million to meet site specific needs.
	Wet Air Oxidation WPRO-215-OG	**Demonstration** The process is commercially available. It is capable of greater than 99+% destruction of some organics however, it may not be able to completely destroy certain refractory organics such as halogenated aromatics (e.g., PCB). Processing costs are likely to be high.	Demonstrate the effectiveness of the technology to meet the site requirements.	The development effort is estimated to require approximately $ 1 million.
Thermal Treatment	Incineration WPRO-108-OG	**Accepted** The EPA considers incineration to be the best demonstrated available technology (BDAT) for the destruction of organics. Incineration can achieve DREs greater than 99.999% for certain organics. However, additional RD&D on several aspects of incineration is still required.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated, Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	Knowledge of process application, funding, and regulatory approval. For example, the K-25 Site TSCA Incinerator is a 30 MMBtu/h unit that is permitted to destroy low-level radioactively contaminated mixed wastes. The unit was built at a capital cost of $ 26 million (1987 dollars). Obtaining regulatory approval for the TSCA Incinerator took over 8 years. The 1992 destruction costs at the incinerator are estimated to be $ 10 per pound of waste incinerated.
	Thermal Desorption WPRO-106-OG	**Accepted** This technology has been used by industry to remove and recover volatiles form contaminated media such as soils. The process is claimed to have a >99% removal efficiency for recovering volatile organic compounds (VOCs) from soil. The application of the process to treat other contaminated media (such as concrete rubble) needs to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application, funding, and regulatory approval.

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternati
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Wastewater	Volatile Organic Compounds in Water	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Thermal Treatment (cont.)

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- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram
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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Thermal Treatment (cont.)	Molten Salt Oxidation WPRO-113-OG	**Demonstration** This is not a new process however, its application for treating hazardous and radioactive contaminants has not been demonstrated. One advantage of the process is that the process and equipment is transportable (as opposed to a fixed treatment facility) and can be located near the waste site. The process should be capable of destroying organics with a >99% efficiency. Additional RD&D is required to fully develop the process to treat mixed wastes.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.4 million for a 3 year development effort.
	Chem Char Process WPRO-114-OG	**Pre-Demonstration** This is a developmental technology based on coal char gasification. The process is claimed to achieve near total destruction of the organics and produces an inert char residue that contains the non-volatile toxic metals and radionuclides. This char residue can either be vitrified to yield a glassy slag or immobilized in cement.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
	Steam Stripping WPRO-221-OG	**Demonstration** This is an accepted industrial process that can remove volatile organics with >99+% efficiency especially from contaminated aqueous streams. The application of the process to satisfactorily remove hazardous and radioactive species needs to be demonstrated.	Demonstrate the effectiveness of the technology to meet the site requirements.	The RD&D effort is estimated to require $ 1-2 million to meet site specific needs.
	Distillation WPRO-222-OG	**Demonstration** This is an accepted industrial process for treating liquids. Depending upon the contaminant being removed, the separation efficiency can be greater than 99%. However, the use of the process to meet site requirements will need to be demonstrated. Capital and operating costs could be high.	The use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
	Evaporation WPRO-223-OG	**Demonstration** This is similar to distillation and is an accepted industrial process for treating contaminated liquids. It is usually used when the solvent is of low value and can be disposed. Like distillation, the operating costs can be high for certain applications.	The use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
	Catalytic Destruction WPRO-109-OG	**Demonstration** This technology has been demonstrated to be effective (DRE>99+%) for the destruction of liquid and gaseous organic wastes. However, its use to remove and destroy the organics from solids needs additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2 million to meet site specific needs.

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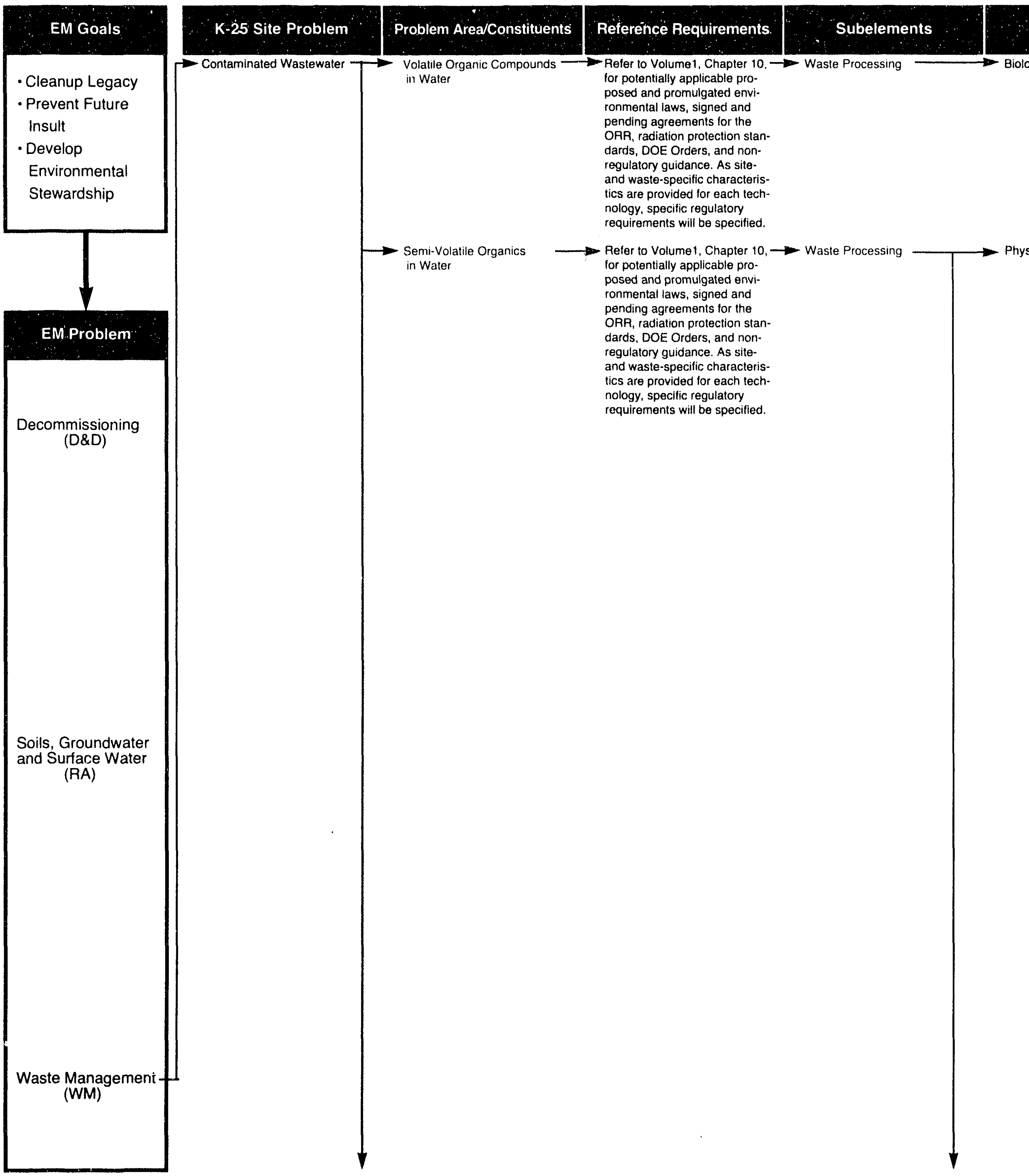

Logic Diagram

Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Biological Treatment	Aerobic Digestion WPRO.224	**Pre-Demonstration** This is a promising technology for destroying hazardous organics. Under the right conditions, this process should be able to achieve greater than 99% destruction of the organics. Additional RD&D is needed to determine the applicability of the process to meet the site requirements.	The use of the technology to meet the site requirements needs to be demonstrated.	The RD&D effort is estimated to require $ 1-2 million to meet site specific needs.
Physical Treatment	Foaming V'PRO-201-OG	**Demonstration** This process is used to recover particulates from liquids (e.g., aqueous streams). Removal efficiencies are generally greater than 90%. The process is a variation of filtration in which chemicals are added to the liquid to create a foam. The foam traps the particulates. The foam is then processed elsewhere to recover the particulates.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Sedimentation WPRO-201-OG	**Demonstration** Sedimentation is also a variation of filtration in which gravity forces are used to remove the particulates from the fluid. Removal efficiencies should generally be greater than 90%.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Reverse Osmosis WPRO-206-OG	**Demonstration** Reverse osmosis is commercial technology for treating aqueous streams. When properly designed and operated the technology is capable of greater than 99% rejection of the salts. However, additional RD&D may be required to develop membranes that meet the site specific requirements.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop applicable membranes is estimated to require $ 0.75 million.
	Ultrafiltration WPRO-206-OG	**Demonstration** Ultrafiltration is also a membrane separation process that is similar to reverse osmosis. However, it will not remove low to intermediate molecular weight solutes from the liquid stream.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop applicable membranes is estimated to require $ 0.75 million.
	Adsorption WPRO-202/203-OG	**Pre-Demonstration** Laboratory studies indicate removal efficiencies greater than 90% for the removal of radioactive species using various adsorbing media. Further development is necessary to develop more effective adsorption media for the treatment of mixed waste contaminated liquids. Development would include for example, scale-up studies, development of high surface area and appropriate particle size media for continuous operations, and the development of appropriate media for the removal of various contaminants.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.

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- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternat
Contaminated Wastewater	Semi-Volatile Organics in Water	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Chemical Treatm

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Treatment	Ozonation-Photolysis WPRO-214-OG	**Demonstration** This process can be very useful in destroying organics (especially refractory organics) in water. DREs for the process can be greater than 90+%. Even though some organics are easily destroyed by the process, they are rarely completely oxidized and may be converted to other hazardous species. To be successful, a thorough knowledge of the waste to be treated is essential. The process is comparatively expensive for the treatment of organics.	The use of the technology to meet the site requirements needs to be demonstrated.	The RD&D effort is estimated to require $ 1-2 million to meet site specific needs.
	Solvent Extraction WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
	Wet Air Oxidation WPRO-215-OG	**Pre-Demonstration** The process is commercially available. It is capable of greater than 99+% destruction of some organics however, it may not be able to completely destroy certain refractory organics such as halogenated aromatics (e.g., PCB). Processing costs are likely to be high.	Demonstrate the effectiveness of the technology to meet the site requirements.	The development effort is estimated to require approximately $ 1 million.
	Gamma-Radiolysis WPRO-100-OG	**Evolving Technology** The radiolytic destruction of halogenated and aromatic compounds at the laboratory scale is well documented. However, its application on an industrial scale needs additional RD&D. The process is capable of high (>90%) destruction efficiencies for organics.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment. Some of the issues to be resolved are the complete characterization of the radiolytic decomposition products under different conditions and for different waste materials and their relative toxicity. Another issue is the possibility of combining the radiolysis with enhanced biodegradation of the radiolytic by products.	The RD&D effort is estimated to require $ 1.25-2.5 million.

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Decommissioning (D&D)

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Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
Contaminated Wastewater	Semi-Volatile Organics in Water	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Therm

Logic Diagram
Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Thermal Treatment	Incineration WPRO-108-OG	**Accepted** The EPA considers incineration to be the best demonstrated available technology (BDAT) for the destruction of organics. Incineration can achieve DREs greater than 99.999% for certain organics. However, additional RD&D on several aspects of incineration is still required.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated. Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	Knowledge of process application, funding, and regulatory approval. For example, the K-25 Site TSCA Incinerator is a 30 MMBtu/h unit that is permitted to destroy low-level radioactively contaminated mixed wastes. The unit was built at a capital cost of $ 26 million (1987 dollars). Obtaining regulatory approval for the TSCA Incinerator took over 8 years. The 1992 destruction costs at the incinerator are estimated to be $ 10 per pound of waste incinerated.
	Chem Char Process WPRO-114-OG	**Pre-Demonstration** This is a developmental technology based on coal char gasification. The process is claimed to achieve near total destruction of the organics and produces an inert char residue that contains the non-volatile toxic metals and radionuclides. This char residue can either be vitrified to yield a glassy slag or immobilized in cement.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
	Molten Salt Oxidation WPRO-113-OG	**Demonstration** This is not a new process however, its application for treating hazardous and radioactive contaminants has not been demonstrated. One advantage of the process is that the process and equipment is transportable (as opposed to a fixed treatment facility) and can be located near the waste site. The process should be capable of destroying organics with a >99% efficiency. Additional RD&D is required to fully develop the process to treat mixed wastes.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.4 million for a 3 year development effort.
	Steam Stripping-OG	**Demonstration** This is an accepted industrial process that can remove volatile organics with >99+% efficiency especially from contaminated aqueous streams. The application of the process to satisfactorily remove hazardous and radioactive species needs to be demonstrated.	Demonstrate the effectiveness of the technology to meet the site requirements.	The RD&D effort is estimated to require $ 1-2 million to meet site specific needs.
	Catalytic Destruction WPRO-109-OG	**Pre-Demonstration** This technology has been demonstrated to be effective (DRE>99+%) for the destruction of liquid and gaseous organic wastes. However, its use to remove and destroy the organics from solids needs additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.

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Waste Managem

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alterna
Contaminated Wastewater	Mercury in Water	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physical Treatme
				Chemical Treatm

Logic Diagram
Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Treatment	Sedimentation WPRO-201-OG	**Demonstration** Sedimentation is also a variation of filtration in which gravity forces are used to remove the particulates from the fluid. Removal efficiencies should generally be greater than 90%.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Filtration WPRO-201-OG	**Demonstration** This is an accepted process for separating solids from fluids. The process can achieve removal efficiencies greater than 99%. The use of the process to meet the site requirements will however, need to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Inorganic Microporous Filters WPRO-207-OG	**Pre-Demonstration** This is novel technology being developed for filtration applications. Some of the advantages of these filters are that they can be used in severe environments, they can be readily cleaned if they get fouled, and they can be re-used indefinitely. Their separation efficiency can be 99%+.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.
	Adsorption WPRO-202/203-OG	**Pre-Demonstration** Laboratory studies indicate removal efficiencies greater than 90% for the removal of radioactive species using various adsorbing media. Further development is necessary to develop more effective adsorption media for the treatment of mixed waste contaminated liquids. Development would include for example, scale-up studies, development of high surface area and appropriate particle size media for continuous operations, and the development of appropriate media for the removal of various contaminants.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
	Electrolysis WPRO-205-OG	**Demonstration** The basic technology is well established in industry however, its application to meet the site requirements needs to be developed and demonstrated. Removal efficiencies for the process are in general greater than 90%.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
Chemical Treatment	Ion Exchange WPRO-217/218-OG	**Demonstration** This is one of the accepted methods used in industry for treating liquids. Treatment efficiencies can be greater than 99% depending upon the application, the ion exchange media, and the solutes to be removed.	The use of the technology to meet the site requirements needs to be demonstrated.	Development costs are estimated to be $ 1.25 million.

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Waste Manag

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Wastewater	Mercury in Water	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Chemic (cont.)
	Contaminated Oil	RAD and Technetium in Oil	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physical

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram
Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Treatment (cont.)	Chemical Fixation WPRO-208-OG	**Demonstration** This process consists of fixing the contaminants by chemical reaction so that they can be removed by filtration or other separation techniques. The process should be capable of 90%+ treatment efficiencies.	Demonstrate the effectiveness of the technology to meet the site requirements.	The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.
Physical Treatment	Centrifugation WPRO-201-OG	**Demonstration** This process is a variation of filtration operations in which centrifugal action is used to separate the heavier components from the lighter fluid. Removal efficiencies are generally greater than 95+%.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Filtration WPRO-201-OG	**Demonstration** This is an accepted process for separating solids from fluids. The process can achieve removal efficiencies greater than 99%. The use of the process to meet the site requirements will however, need to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Foaming WPRO-201-OG	**Demonstration** This process is used to recover particulates from liquids (e.g., aqueous streams). Removal efficiencies are generally greater than 90%. The process is a variation of filtration in which chemicals are added to the liquid to create a foam. The foam traps the particulates. The foam is then processed elsewhere to recover the particulates.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Inorganic Microporous Filters WPRO-207-OG	**Pre-Demonstration** This is novel technology being developed for filtration applications. Some of the advantages of these filters are that they can be used in severe environments, they can be readily cleaned if they get fouled, and they can be re-used indefinitely. Their separation efficiency can be 99%+.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.
	HGMS WPRO-204-OG	**Demonstration** The treatment is commercially available for example, for the removal of trace impurities from kaolin clays. Removal efficiencies for the process are greater than 99%. However, its use to treat mixed waste contaminated fluids needs additional RD&D.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to be $ 0.5-1 million.

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alterna
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Oil	RAD and Technetium in Oil	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physical Treatme (cont.) Chemical Treatm

EM Problem

Decommissioning (D&D)

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Waste Management (WM)

Logic Diagram
Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Treatment (cont.)	Adsorption WPRO-202/203-OG	**Pre-Demonstration** Laboratory studies indicate removal efficiencies greater than 90% for the removal of radioactive species using various adsorbing media. Further development is necessary to develop more effective adsorption media for the treatment of mixed waste contaminated liquids. Development would include for example, scale-up studies, development of high surface area and appropriate particle size media for continuous operations, and the development of appropriate media for the removal of various contaminants.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
Chemical Treatment	Chemical Precipitation WPRO-210-OG	**Demonstration** Precipitation technologies are fairly mature. Iron co-precipitation is presently being used at the K-25 Site Central Neutralization Facility for separating radionuclides from the aqueous wastes. However, significant development is still necessary to meet the increasingly stringent regulatory limits on the wastewater discharges. For example, precipitation using potassium ferrate has not been demonstrated and additional RD&D is required to prove its applicability and performance in treating the wastewater.	Demonstrate the effectiveness of the technology to meet the site requirements.	The demonstration effort is estimated to require $ 0.4 million.
	Solvent Extraction WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Oil	RAD and Technetium in Oil	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Chemic (cont.) Therma

EM Problem

- Decommissioning (D&D)
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- Waste Management (WM)

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Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Treatment (cont.)	Acid Stripping WPRO-213-OG	**Demonstration** This is an accepted technology in industry with removal efficiencies greater than 99% however, each application requires additional RD&D to determine optimum leachant composition and process conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	Demonstrate the effectiveness of the technology to meet the site requirements.
	Bucky Ball Chemistry WPRO-101-OG	**Evolving Technology** This is a novel technology that has many potential applications in fields such as mixed wastes treatment, nuclear medicine, tribology, and material science. Conceptually, the technology is sophisticated (uses lasers) and yet simple. For mixed wastes treatment, the process would essentially encapsulate the radioactive and hazardous metals at the elemental level in high molecular weight carbon cages (called fullerenes) thereby isolating them from the environment.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop the technology is estimated to require $ 10 million. The payback is estimated to be in the range of $ 150 million considering savings in waste treatment and disposal costs and potential spinoffs in other fields such as nuclear medicine and new materials.
Thermal Treatment	Incineration WPRO-108-OG	**Accepted** The EPA considers incineration to be the best demonstrated available technology (BDAT) for the destruction of organics. Incineration can achieve DREs greater than 99.999% for certain organics. However, additional RD&D on several aspects of incineration is still required.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated. Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	Knowledge of process application, funding, and regulatory approval. For example, the K-25 Site TSCA Incinerator is a 30 MMBtu/h unit that is permitted to destroy low-level radioactively contaminated mixed wastes. The unit was built at a capital cost of $ 26 million (1987 dollars). Obtaining regulatory approval for the TSCA Incinerator took over 8 years. The 1992 destruction costs at the incinerator are estimated to be $ 10 per pound of waste incinerated.
	Chem Char Process WPRO-114-OG	**Pre-Demonstration** This is a developmental technology based on coal char gasification. The process is claimed to achieve near total destruction of the organics and produces an inert char residue that contains the non-volatile toxic metals and radionuclides. This char residue can either be vitrified to yield a glassy slag or immobilized in cement.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
	Molten Salt Oxidation WPRO-113-OG	**Demonstration** This is not a new process however, its application for treating hazardous and radioactive contaminants has not been demonstrated. One advantage of the process is that the process and equipment is transportable (as opposed to a fixed treatment facility) and can be located near the waste site. The process should be capable of destroying organics with a >99% efficiency. Additional RD&D is required to fully develop the process to treat mixed wastes.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.4 million for a 3 year development effort.

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K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Altern
Contaminated Oil	RAD and Technetium in Oil	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Biotreatment
	Heavy Metals in Oil	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physical Treatm

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Biotreatment	Biosorption WPRO-226-OG	**Pre-Demonstration** Data in the scientific literature suggests that given the right conditions, this process should be able to achieve impressive (>95%) treatment efficiencies however, most of the information is based on laboratory-scale data. There is little pilot plant or indı strial scale data on the process.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-3 million.
Physical Treatment	Centrifugation WPRO-201-OG	**Demonstration** This process is a variation of filtration operations in which centrifugal action is used to separate the heavier components from the lighter fluid. Removal efficiencies are generally greater than 95+%.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated tc :equire up to $ 1 million.
	Decantation WPRO-201-OG	**Demonstration** This is an accepted process for the separating solids from liquids. The removal efficiency for the process can vary from 80 to 90+% depending upon the materials being separated.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated tɔ require up to $ 1 million.
	Filtration WPRO-201-OG	**Demonstration** This is an accepted process for separating solids from fluids. The process can achieve removal efficiencies greater than 99%. The use of the process to meet the site requirements will however, need to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Foaming WPRO-201-OG	**Demonstration** This process is used to recover particulates from liquids (e.g., aqueous streams). Removal efficiencies are generally greater than 90%. The process is a variation of filtration in which chemicals are added to the liquid to create a foam. The foam traps the particulates. The foam is then processed elsewhere to recover the particulates.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Ultrafiltration WPRO-206-OG	**Demonstration** Ultrafiltration is also a membrane separation process that is similar to reverse osmosis. However, it will not remove low to intermediate molecular weight solutes from the liquid stream.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
	Electrolysis WPRO-205-OG	**Demonstration** The basic technology is well established in industry however, its application to meet the site requirements needs to be developed and demonstrated. Removal efficiencies for the process are in general greater than 90%.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.

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K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
Contaminated Oil	Heavy Metals in Oil	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physic (cont.)
				Chemi

Logic Diagram
Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Treatment (cont.)	HGMS WPRO-204-OG	**Demonstration** The treatment is commercially available for example, for the removal of trace impurities from kaolin clays. Removal efficiencies for the process are greater than 99%. However, it ; use to treat mixed waste contaminated fluids needs additional RD&D.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to be $ 0.5-1 million.
	Inorganic Microporous Filters WPRO-207-OG	**Pre-Demonstration** This is novel technology being developed for filtration applications. Some of the advantages of these filters are that they can be used in severe environments, they can be readily cleaned if they get fouled, and they can be re-used indefinitely. Their separation efficiency can be 99%+.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.
	Adsorption WPRO-202/203-OG	**Demonstration** Laboratory studies indicate removal efficiencies greater than 90% for the removal of radioactive species using various adsorbing media. Further development is necessary to develop more effective adsorption media for the treatment of mixed waste contaminated liquids. Development would include for example, scale-up studies, development of high surface area and appropriate particle size media for continuous operations, and the development of appropriate media for the removal of various contaminants.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
Chemical Treatment	Chemical Precipitation WPRO-210-OG	**Demonstration** Precipitation technologies are fairly mature. Iron co-precipitation is presently being used at the K-25 Site Central Neutralization Facility for separating radionuclides from the aqueous wastes. However, significant development is still necessary to meet the increasingly stringent regulatory limits on the wastewater discharges. For example, precipitation using potassium ferrate has not been demonstrated and additional RD&D is required to prove its applicability and performance in treating the wastewater.	Demonstrate the effectiveness of the technology to meet the site requirements.	The demonstration effort is estimated to require $ 0.4 million.

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K-25 Site Problem

Contaminated Oil

Problem Area/Constituents

Heavy Metals in Oil

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelements

Waste Processing

Alternat

Chemical Treatm

Thermal Treatme

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Treatment	Solvent Extraction WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
	Acid Stripping WPRO-213-OG	**Demonstration** This is an accepted technology in industry with removal efficiencies greater than 99% however, each application requires additional RD&D to determine optimum leachant composition and process conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology tc deployment	Demonstrate the effectiveness of the technology to meet the site requirements.
	Bucky Ball Chemistry WPRO-101-OG	**Evolving Technology** This is a novel technology that has many potential applications in fields such as mixed wastes treatment, nuclear medicine, tribology, and material science. Conceptually, the technology is sophisticated (uses lasers) and yet simple. For mixed wastes treatment, the process would essentially encapsulate the radioactive and hazardous metals at the elemental level in high molecular weight carbon cages (called fullerenes) thereby isolating them from the environment.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop the technology is estimated to require $ 10 million. The payback is estimated to be in the range of $ 150 million considering savings in waste treatment and disposal costs and potential spinoffs in other fields such as nuclear medicine and new materials.
Thermal Treatment	Incineration WPRO-108-OG	**Accepted** The EPA considers incineration to be the best demonstrated available technology (BDAT) for the destruction of organics. Incineration can achieve DREs greater than 99.999% for certain organics. However, additional RD&D on several aspects of incineration is still required.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated, Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	Knowledge of process application, funding, and regulatory approval. For example, the K-25 Site TSCA Incinerator is a 30 MMBtu/h unit that is permitted to destroy low-level radioactively contaminated mixed wastes. The unit was built at a capital cost of $ 26 million (1987 dollars). Obtaining regulatory approval for the TSCA Incinerator took over 8 years. The 1992 destruction costs at the incinerator are estimated to be $ 10 per pound of waste incinerated.

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Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
Contaminated Oil	Heavy Metals in Oil	R fer to Volume1, Chapter 10, ..r potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Ther (con
				BioTre
	PCB in Oil	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physic
				Chemic

Thermal Treatment (cont.)	Chem Char Process WPRO-114-OG	**Pre-Demonstration** This is a developmental technology based on coal char gasification. The process is claimed to achieve near total destruction of the organics and produces an inert char residue that contains the non-volatile toxic metals and radionuclides. This char residue can either be vitrified to yield a glassy slag or immobilized in cement.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
	Molten Salt Oxidation WPRO-113-OG	**Pre-Demonstration** This is not a new process however, its application for treating hazardous and radioactive contaminants has not been demonstrated. One advantage of the process is that the process and equipment is transportable (as opposed to a fixed treatment facility) and can be located near the waste site. The process should be capable of destroying organics with a >99% efficiency. Additional RD&D is required to fully develop the process to treat mixed wastes.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.4 million for a 3 year development effort.
BioTreatment	Biosorption WPRO-226-OG	**Pre-Demonstration** Data in the scientific literature suggests that given the right conditions, this process should be able to achieve impressive (>95%) treatment efficiencies however, most of the information is based on laboratory-scale data. There is little pilot plant or industrial scale data on the process.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-3 million.
Physical Treatment	Adsorption WPRO-202/203-OG	**Pre-Demonstration** Laboratory studies indicate removal efficiencies greater than 90% for the removal of radioactive species using various adsorbing media. Further development is necessary to develop more effective adsorption media for the treatment of mixed waste contaminated liquids. Development would include for example, scale-up studies, development of high surface area and appropriate particle size media for continuous operations, and the development of appropriate media for the removal of various contaminants.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
Chemical Treatment	Solvent Extraction WPRO-211/212-OG	**Demonstration** The RD&D effort is estimated to require $ 5-10 million. The payback could be significant.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
	Stripping WPRO-213-OG	**Demonstration** The use of the technology to meet the site requirements needs to be demonstrated.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	Demonstrate th effectiveness of the technology to meet the site requirements.

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternati
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Oil	PCB in Oil	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Chemical Treatmen (cont.) Thermal Treatment Biological Treatmen
		Non-Halogenated Organics in Oil	Refer to Volume1, Chapter 6, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physical Treatment

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- Decommissioning (D&D)
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- Waste Management (WM)

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Logic Diagram
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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Treatment (cont.)	Chemical Precipitation WPRO-210-OG	**Demonstration** The development effort is estimated to require approximately $ 1 million.	Demonstrate the effectiveness of the technology to meet the site requirements.	The demonstration effort is estimated to require $ 0.4 million.
	Supercritical Water Oxidation WPRO-216-OG	**Demonstration**	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment. The RD&D effort is estimated to require $ 2.5 million.	The RD&D effort is estimated to require $ 1.6 million for a 3 year development plan.
	Chemical Dechlorination WPRO-209-OG	**Pre-Demonstration** Knowledge of process application(s) and funding.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25-2.5 million.
Thermal Treatment	Incineration WPRO-108-OG	**Accepted** The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated, Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	Knowledge of process application, funding, and regulatory approval. The RD&D effort is estimated to require $ 1.25-2.5 million.
	Molten Salt Oxidation WPRO-113-OG	**Demonstration** Further RD&D on the process is needed to develop the optimum processing conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.4 million for a 3 year development effort.
	Chem Char Process WPRO-114-OG	**Pre-Demonstration** The RD&D effort is estimated to require $ 5 million for a 3-year R&D program.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
	Distillation WPRO-222-OG	**Demonstration** Demonstration costs are estimated to be $ 0.5-1 million.	The use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
Biological Treatment	Microbial Dechlorination WPRO-227-OG	**Evolving Technology** This process is at an early stage of development. Based on the available information, it appears the process should be able to achieve destruction efficiencies greater than 90%.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 5-10 million. The payback could be significant.
	Aerobic Digestion WPRO-224-OG	**Demonstration** This is a promising technology for destroying hazardous organics. Under the right conditions, this process should be able to achieve greater than 99% destruction of the organics. Additional RD&D is needed to determine the applicability of the process to meet the site requirements.	The use of the technology to meet the site requirements needs to be demonstrated.	The RD&D effort is estimated to require $ 1-2 million to meet site specific needs.
Physical Treatment	Centrifugation WPRO-201-OG	**Demonstration** This process is a variation of filtration operations in which centrifugal action is used to separate the heavier components from the lighter fluid. Removal efficiencies are generally greater than 95+%.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.

Technology Lo

Waste Manag

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

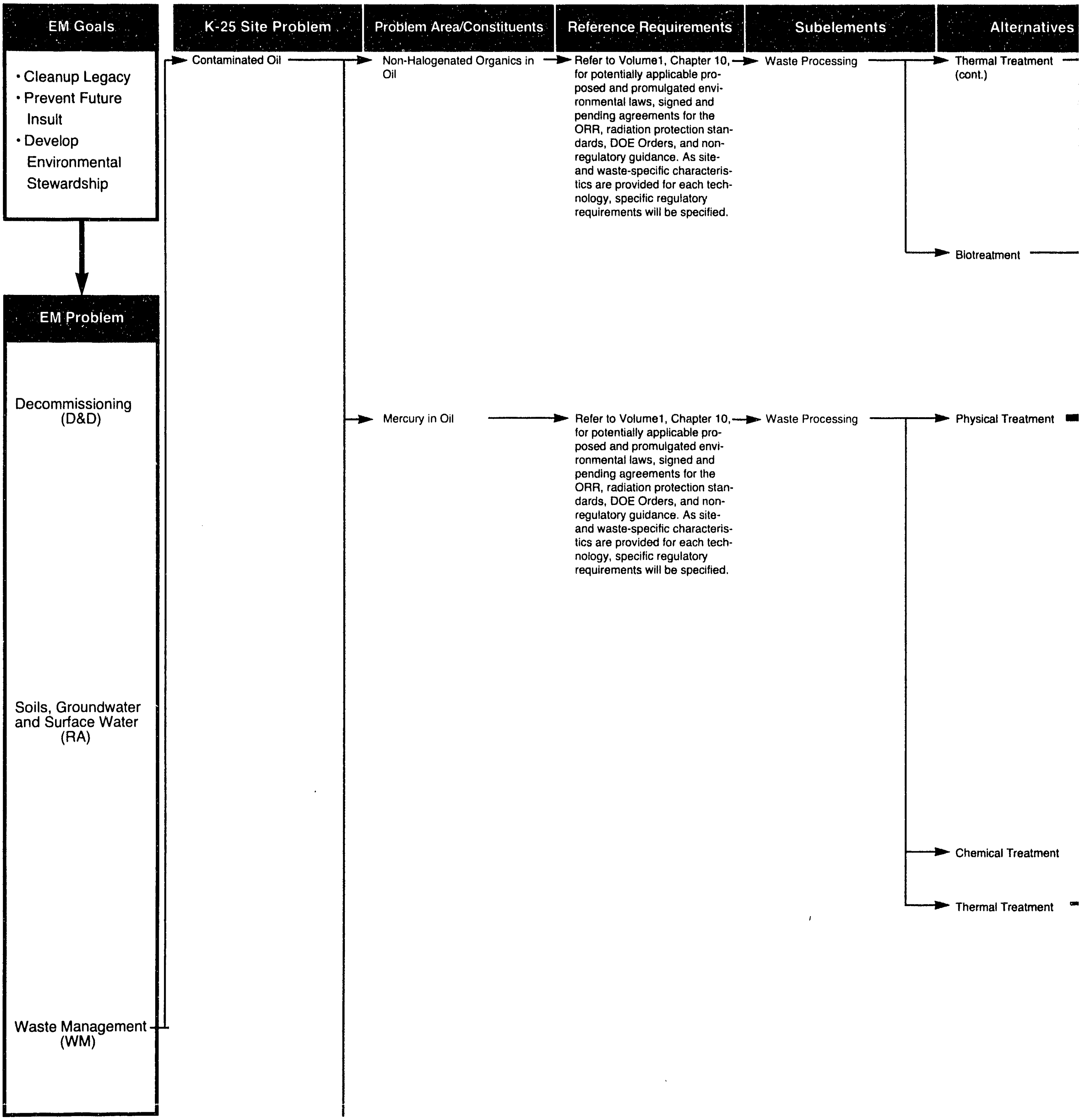
Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
Contaminated Oil	Non-Halogenated Organics in Oil	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physica (cont.)
				Chemic
				Therma

Logic Diagram
Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Treatment (cont.)	Decantation WPRO-201-OG	**Demonstration** This is an accepted process for the separating solids from liquids. The removal efficiency for the process can vary from 80 to 90+% depending upon the materials being separated.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Gravity Separation WPRO-201-OG	**Demonstration** Sedimentation is also a variation of filtration in which gravity forces are used to remove the particulates from the fluid. Removal efficiencies should generally be greater than 90%.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Adsorption WPRO-202/203-OG	**Pre-Demonstration** The RD&D effort is estimated to require $ 1-10 million. The payback could be significant.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
Chemical Treatment	Solvent Extraction WPRO-211/212-OG	**Demonstration** The RD&D effort is estimated to require $ 5-10 million. The payback could be significant.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
	Acid Leaching WPRO-213-OG	**Demonstration** The use of the technology to meet the site requirements needs to be demonstrated.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	Demonstrate the effectiveness of the technology to meet the site requirements.
	Gamma Radiolysis WPRO-100-OG	**Evolving Technology** The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment. Demonstrate the effectiveness of the technology to meet the site requirements.	The RD&D effort is estimated to require $ 1.25-2.5 million.
	Supercritical Water Oxidation WPRO-216-OG	**Demonstration**	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment. The RD&D effort is estimated to require $ 2.5 million.	The RD&D effort is estimated to require $ 1.6 million for a 3 year development plan.
Thermal Treatment	Distillation WPRO-222-OG	**Demonstration** This is an accepted industrial process for treating liquids. Depending upon the contaminant being removed, the separation efficiency can be greater than 99%. However, the use of the process to meet site requirements will need to be demonstrated. Capital and operating costs could be high.	The use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
	Incineration WPRO-108-OG	**Accepted** The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated. Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	Knowledge of process application, funding, and regulatory approval. The RD&D effort is estimated to require $ 1.25-2.5 million.
	Chem Char Process WPRO-114-OG	**Pre-Demonstration** The RD&D effort is estimated to require $ 5 million for a 3-year R&D program.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.

Technology Logic
Waste Managemen



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·s	Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
	Thermal Treatment (cont.)	Molten Salt Oxidation WPRO-113-OG	**Demonstration** Further RD&D on the process is needed to develop the optimum processing conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.4 million for a 3 year development effort.
		Low Temperature Separation WPRO-220-OG	**Pre-Demonstration** This is an accepted industrial process for the separation of low-boiling components from high-boiling components. The process can achieve separation efficiencies greater than 99%.	Further RD&D on the process is needed to develop the optimum processing conditions.	The RD&D effort is estimated to require $ 1-2 million to meet site specific needs.
	Biotreatment	Anaerobic Digestion WPRO-224-OG	**Pre-Demonstration** This is a promising technology for destroying hazardous organics. Under the right conditions, this process should be able to achieve greater than 99% destruction of the organics. Additional RD&D is needed to determine the applicability of the process to meet the site requirements.	The use of the technology to meet the site requirements needs to be demonstrated.	The RD&D effort is estimated to require $ 1-2 million to meet site specific needs.
	Physical Treatment	Decantation WPRO-201-OG	**Demonstration** This is an accepted process for the separating solids from liquids. The removal efficiency for the process can vary from 80 to 90+% depending upon the materials being separated.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
		Filtration WPRO-201-OG	**Demonstration** This is an accepted process for separating solids from fluids. The process can achieve removal efficiencies greater than 99%. The use of the process to meet the site requirements will however, need to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
		Gravity Separation WPRO-201-OG	**Demonstration** The use of the technology to meet the site requirements needs to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
		Centrifugation WPRO-201-OG	**Demonstration** This process is a variation of filtration operations in which centrifugal action is used to separate the heavier components from the lighter fluid. Removal efficiencies are generally greater than 95+%.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Chemical Treatment	Chemical Fixation WPRO-208-OG	**Pre-demonstration** Development costs are estimated to be $ 1.25 million.	Demonstrate the effectiveness of the technology to meet the site requirements.	The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.
	Thermal Treatment	Thermal Desorption WPRO-106-OG	**Demonstration** Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated. Also, need to develop better understanding of the immobilization chemistry and mechanisms.	The use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application, funding, and regulatory approval.
		Molten Salt Oxidation WPRO-113-OG	Pre-demonstration Further RD&D on the process is needed to develop the optimum processing conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.4 million for a 3 year development effort.

Technology Lo
Waste Manag

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Solvents (Halogenated and Non-Halogenated)	RAD in Solvents	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physic
					Chemic

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

Logic Diagram
Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Treatment	Filtration WPRO-201-OG	**Demonstration** This is an accepted process for separating solids from fluids. The process can achieve removal efficiencies greater than 99%. The use of the process to meet the site requirements will however, need to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Centrifugation WPRO-201-OG	**Demonstration** This process is a variation of filtration operations in which centrifugal action is used to separate the heavier components from the lighter fluid. Removal efficiencies are generally greater than 95+%.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Foaming WPRO-201-OG	**Demonstration** Develop and demonstrate the effectiveness of the WMES to minimize site wastes and waste disposal costs.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Ultrafiltration WPRO-206-OG	**Demonstration** The RD&D effort to develop applicable membranes is estimated to require $ 0.75 million.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop applicable membranes is estimated to require $ 0.75 million.
	Electrolysis WPRO-205-OG	**Demonstration** An industrial-scale national transmutation facility would need to be developed and built. The cost for such a "national" facility is estimated to be in the billion dollars range and would require several years to build.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
	HGMS WPRO-204-OG	**Demonstration** The implementation needs will be determined by the site requirements.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to be $ 0.5-1 million.
	Inorganic Microporous Filters WPRO-207-OG	**Pre-Demonstration** The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.
	Adsorption WPRO-202/203-OG	**Demonstration** The RD&D effort is estimated to require $ 1-10 million. The payback could be significant.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
Chemical Treatment	Chemical Precipitation WPRO-210-OG	**Demonstration** The development effort is estimated to require approximately $ 1 million.	Demonstrate the effectiveness of the technology to meet the site requirements.	The demonstration effort is estimated to require $ 0.4 million.
	Chemical Fixation WPRO-208-OG	**Demonstration** Development costs are estimated to be $ 1.25 million.	Demonstrate the effectiveness of the technology to meet the site requirements.	The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.
	Solvent Extraction WPRO-211/212-OG	**Demonstration** The RD&D effort is estimated to require $ 5-10 million. The payback could be significant.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.

Technology Logic

Waste Manageme

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternativ
Contaminated Solvents (Halogenated and Non-Halogenated)	RAD in Solvents	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Chemical Treatment (cont.)
				Thermal Treatment
	Heavy Metals in Solvents	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physical Treatment

Logic Diagram
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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Treatment (cont.)	Acid Stripping WPRO-213-OG	**Demonstration** The use of the technology to meet the site requirements needs to be demonstrated.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	Demonstrate the effectiveness of the technology to meet the site requirements.
	Bucky Ball Chemistry WPRO-101-OG	**Evolving Technology** The RD&D effort is estimated to require $ 2-5 million. The payback is expected to be significant especially because the scrap aluminum from the site can be used to dispose of the nitrate wastes in the Hanford site tanks. This is expected to result in significant savings due to minimizing the wastes to be disposed at the two sites.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop the technology is estimated to require $ 10 million. The payback is estimated to be in the range of $ 150 million considering savings in waste treatment and disposal costs and potential spinoffs in other fields such as nuclear medicine and new materials.
Thermal Treatment	Incineration WPRO-108-OG	**Accepted** The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated. Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	Knowledge of process application, funding, and regulatory approval. The RD&D effort is estimated to require $ 1.25-2.5 million.
	Distillation WPRO-222-OG	**Demonstration** Demonstration costs are estimated to be $ 0.5-1 million.	The use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
	Chem Char Process WPRO-114-OG	**Pre-Demonstration** The RD&D effort is estimated to require $ 5 million for a 3-year R&D program.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
	Molten Salt Oxidation WPRO-113-OG	**Demonstration** Further RD&D on the process is needed to develop the optimum processing conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.4 million for a 3 year development effort.
Physical Treatment	Centrifugation WPR-.201-OG	**Demonstration** This process is a variation of filtration operations in which centrifugal action is used to separate the heavier components from the lighter fluid. Removal efficiencies are generally greater than 95+%.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Filtration WPRO-201-OG	**Demonstration** This is an accepted process for separating solids from fluids. The process can achieve removal efficiencies greater than 99%. The use of the process to meet the site requirements will however, need to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Foaming WPRO-201-OG	**Demonstration** Develop and demonstrate the effectiveness of the WMES to minimize site wastes and waste disposal costs.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.

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Waste Manag

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem

Contaminated Solvents (Halogenated and Non-Halogenated)

Problem Area/Constituents

Heavy Metals in Solvents

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelements

Waste Processing

Physic (cont.)

Chemic

Thermal

ʼ Logic Diagram
ꞈ Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Treatment (cont.)	Ultrafiltration WPRO-206-OG	**Demonstration** The RD&D effort to develop applicable membranes is estimated to require $ 0.75 million.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop applicable membranes is estimated to require $ 0.75 million.
	Electrolysis WPRO-205-OG	**Demonstration** The basic technology is well established in industry however, its application to meet the site requirements needs to be developed and demonstrated. Removal efficiencies for the process are in general greater than 90%.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
	HGMS WPRO-204-OG	**Demonstration** The implementation needs will be determined by the site requirements.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to be $ 0.5-1 million.
	Inorganic Microporous Filters WPRO-207-OG	**Pre-Demonstration** The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.
	Adsorption WPRO-202/203-OG	**Demonstration** The RD&D effort is estimated to require $ 1-10 million. The payback could be significant.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
Chemical Treatment	Ion Exchange WPRO-217/218-OG	**Demonstration** The RD&D effort is estimated to require $ 1-3 million.	The use of the technology to meet the site requirements needs to be demonstrated.	Development costs are estimated to be $ 1.25 million.
	Chemical Precipitation WPRO-210-OG	**Accepted** The development effort is estimated to require approximately $ 1 million.	Demonstrate the effectiveness of the technology to meet the site requirements.	The demonstration effort is estimated to require $ 0.4 million.
	Chemical Fixation WPRO-208-OG	**Demonstration** Development costs are estimated to be $ 1.25 million.	Demonstrate the effectiveness of the technology to meet the site requirements.	The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.
	Acid Stripping WPRO-213-OG	**Demonstration** The use of the technology to meet the site requirements needs to be demonstrated.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	Demonstrate the effectiveness of the technology to meet the site requirements.
	Bucky Ball Chemistry WPRO-101-OG	**Evolving Technology** The RD&D effort is estimated to require $ 2-5 million. The payback is expected to be significant especially because the scrap aluminum from the site can be used to dispose of the nitrate wastes in the Hanford site	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop the technology is estimated to require $ 10 million. The payback is estimated to be in the range of $ 150 million considering savings in waste treatment and disposal costs and potential spinoffs in other fields such as nuclear medicine and new materials.
Thermal Treatment	Incineration WPRO-108-OG	**Demonstration** The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated, Also, RD&D is required to develop better understanding	Knowledge of process application, funding, and regulatory approval. The RD&D effort is estimated to require $ 1.25-2.5 million.
	Chem Char Process WPRO-114-OG	**Pre-Demonstration** The RD&D effort is estimated to require $ 5 million for a 3-year R&D program.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.

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Waste Managen

EM Goals	⁄K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Altern
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Solvents (Halogenated and Non-Halogenated)	Heavy Metals in Solvents	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Thermal Treatn (cont.) BioTreatment
		PCB in Solvents	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physical Treatr Chemical Treat

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Thermal Treatment (cont.)	Molten Salt Oxidation WPRO-113-OG	**Demonstration** Further RD&D on the process is needed to develop the optimum processing conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.4 million for a 3 year development effort.
BioTreatment	Biosorption WPRO-226-OG	**Pre-Demonstration** The RD&D effort is estimated to require $ 1.5-2 million to further develop the process to meet the site needs.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-3 million.
Physical Treatment	Decantation WPRO-201-OG	**Demonstration** This is an accepted process for the separating solids from liquids. The removal efficiency for the process can vary from 80 to 90+% depending upon the materials being separated.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Foaming WPRO-201-OG	**Demonstration** Develop and demonstrate the effectiveness of the WMES to minimize site wastes and waste disposal costs.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Filtration WPRO-201-OG	**Demonstration** This is an accepted process for separating solids from fluids. The process can achieve removal efficiencies greater than 99%. The use of the process to meet the site requirements will however, need to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Adsorption WPRO-202/203-OG	**Demonstration** The RD&D effort is estimated to require $ 1-10 million. The payback could be significant.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
Chemical Treatment	Solvent Extraction WPRO-211/212-OG	**Demonstration** The RD&D effort is estimated to require $ 5-10 million. The payback could be significant.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
	Gamma-Radiolysis WPRO-100-OG	**Evolving Technology** The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment. Demonstrate the effectiveness of the technology to meet the site requirements.	The RD&D effort is estimated to require $ 1.25-2.5 million.
	Chemical Dechlorination WPRO-209-OG	**Pre-Demonstration** Knowledge of process application(s) and funding.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25-2.5 million.
	Stripping WPRO-213-OG	**Demonstration** The use of the technology to meet the site requirements needs to be demonstrated.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	Demonstrate the effectiveness of the technology to meet the site requirements.

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Waste Mana M

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Solvents (Halogenated and Non-Halogenated)	PCB in Solvents	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided fo. each technology, specific regulatory requirements will be specified.	Waste Processing	Therm Biotre
	Contaminated Mercury	RAD (including Tc) in Mercury	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physic Chemic Therma
	Contaminated Specialty Freons	• Freons • RAD • Oils • Metals	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physica

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Thermal Treatment	Incineration WPRO-108-OG	**Accepted** The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated, Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	Knowledge of process application, funding, and regulatory approval. The RD&D effort is estimated to require $ 1.25-2.5 million.
	Molten Salt Oxidation WPRO-113-OG	**Demonstration** Further RD&D on the process is needed to develop the optimum processing conditions.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.4 million for a 3 year development effort.
	Distillation WPRO-222-OG	**Demonstration** Demonstration costs are estimated to be $ 0.5-1 million.	The use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
	Chem Char Process WPRO-114-OG	**Pre-Demonstration** The RD&D effort is estimated to require $ 5 million for a 3-year R&D program.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
Biotreatment	Microbial Dechlorination WPRO-227-OG	**Evolving Technology** This process is at an early stage of development. Based on the available information, it appears the process should be able to achieve destruction efficiencies greater than 90%.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 5-10 million. The payback could be significant.
Physical Treatment	Gravity Separation WPRO-201-OG	**Demonstration** Development and demonstration of the WMES is estimated to require $ 3-5 million. The savings from implementing the system could be around $ 1 billion or more.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
Chemical Treatment	Leaching WPRO-213-OG	**Demonstration** The use of the technology to meet the site requirements needs to be demonstrated.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	Demonstrate the effectiveness of the technology to meet the site requirements.
	Chemical Precipitation WPRO-21-OG	**Demonstration** The development effort is estimated to require approximately $ 1 million.	Demonstrate the effectiveness of the technology to meet the site requirements.	The demonstration effort is estimated to require $ 0.4 million.
Thermal Treatment	Distillation WPRO-222-OG	**Demonstration** Demonstration costs are estimated to be $ 0.5-1 million.	The use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
Physical Treatment	Gravity Separation WPRO-201-OG	**Demonstration** Development and demonstration of the WMES is estimated to require $ 3-5 million. The savings from implementing the system could be around $ 1 billion or more.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Filtration WPRO-201-OG	**Demonstration** This is an accepted process for separating solids from fluids. The process can achieve removal efficiencies greater than 99%. The use of the process to meet the site requirements will however, need to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.

Technology Logic

Waste Managemen

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternatives
Contaminated Specialty Freons	• Freons • RAD • Oils • Metals	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physical Treatment (cont.) Chemical Treatment Thermal Treatment

Logic Diagram
Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Treatment (cont.)	Inorganic Microporous Filters WPRO-201-OG	**Pre-Demonstration** The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.
	Adsorption WPRO-202/203-OG	**Pre-Demonstration** The RD&D effort is estimated to require $ 1-10 million. The payback could be significant.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
Chemical Treatment	Solvent Extraction WPRO-211/212-OG	**Demonstration** The RD&D effort is estimated to require $ 5-10 million. The payback could be significant.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
Thermal Treatment	Distillation WPRO-222-OG	**Demonstration** Demonstration costs are estimated to be $ 0.5-1 million.	The use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
	Evaporation WPRO-223-OG	**Demonstration** Demonstration costs are estimated to require up to $ 1 million.	The use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
	Chem Char Process WPRO-114-OG	**Pre-Demonstration** The RD&D effort is estimated to require $ 5 million for a 3-year R&D program.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.

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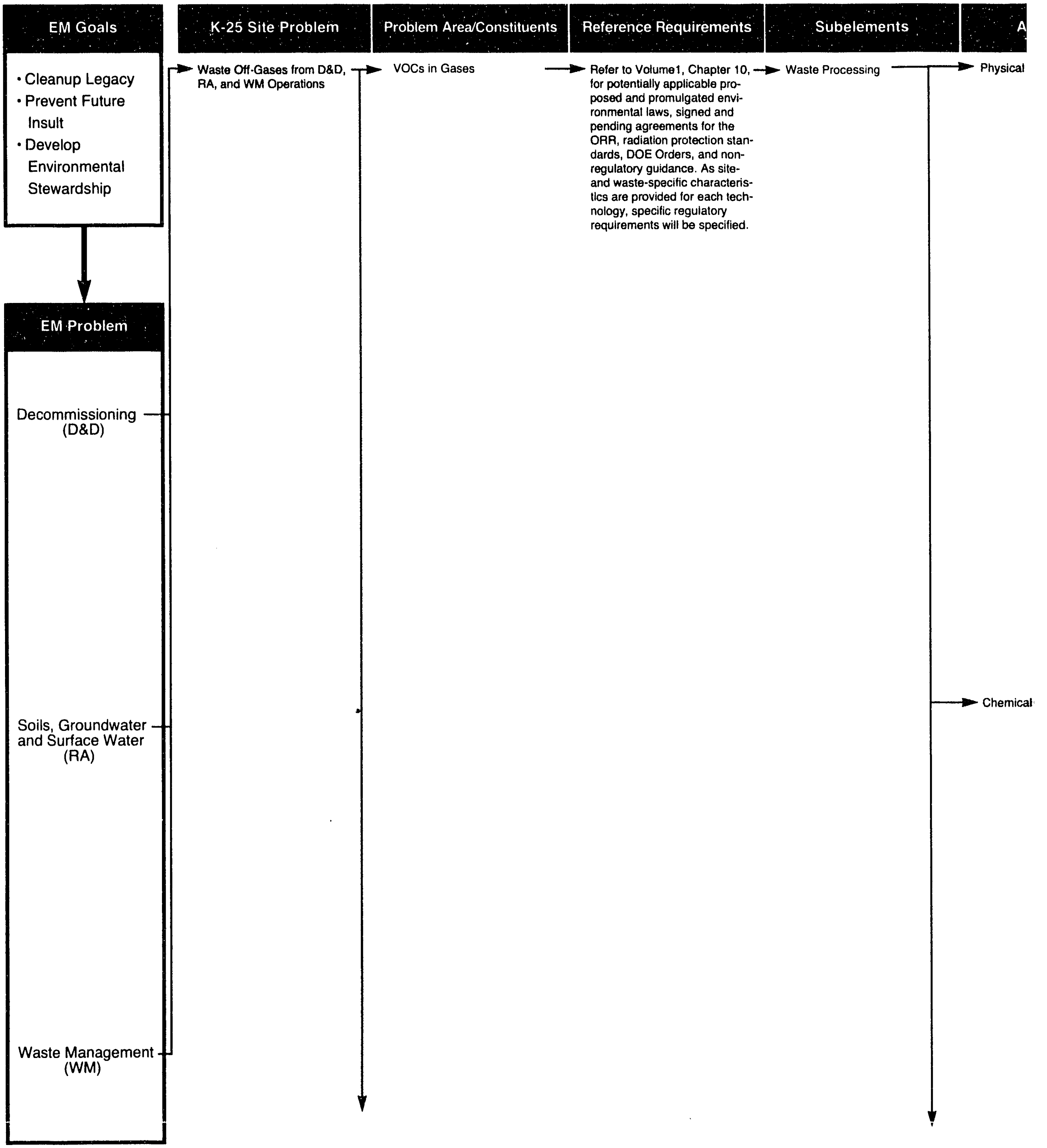

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Treatment	Low Temperature Separation WPRO-220-OG	**Pre-Demonstration** This is an accepted industrial process for the separation of low-boiling components from high-boiling components. The process can achieve separation efficiencies greater than 99%.	Further RD&D on the process is needed to develop the optimum processing conditions.	The RD&D effort is estimated to require $ 1-2 million to meet site specific needs.
	Inorganic Membrane Separation WPRO-300-OG	**Pre-Demonstration** The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.5-2 million to further develop the process to meet the site needs.
	Adsorption WPRO-202/203-OG	**Pre-Demonstration** Laboratory studies indicate removal efficiencies greater than 90% for the removal of radioactive species using various adsorbing media. Further development is necessary to develop more effective adsorption media for the treatment of mixed waste contaminated liquids. Development would include for example, scale-up studies, development of high surface area and appropriate particle size media for continuous operations, and the development of appropriate media for the removal of various contaminants.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
	Scrubbers WPRO-301-OG	**Demonstration** Scrubbers are comercially available though need to be demonstrated for particular applications at K-25.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
Chemical Treatment	Solvent Scrubbing WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Waste Off-Gases from D&D, RA, and WM Operations	VOCs in Gases	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Thermal
		Non-Volatile Organics in Gases	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physical

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram
Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Thermal Treatment	Incineration WPRO-108-OG	**Accepted** The EPA considers incineration to be the best demonstrated available technology (BDAT) for the destruction of organics. Incineration can achieve DREs greater than 99.999% for certain organics. However, additional RD&D on several aspects of incineration is still required.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated, Also, RD&D is required to develop better understanding of the process technology to improve its acceptability.	Knowledge of process application, funding, and regulatory approval.
	Catalytic Destruction WPRO-109-OG	**Pre-Demonstration** This technology has been demonstrated to be effective (DRE>99+%) for the destruction of liquid and gaseous organic wastes. However, its use to remove and destroy the organics from solids needs additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
	Molten Salt Oxidation WPRO-113-OG	**Demonstration** This is not a new process however, its application fo, treating hazardous and radioactive contaminants has not been demonstrated. One advantage of the process is that the process and equipment is transportable (as opposed to a fixed treatment facility) and can be located near the waste site. The process should be capable of destroying organics with a >99% efficienc. Additional RD&D is required to fully develop the process to treat mixed wastes.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.4 million for a 3 year development effort.
	Electron Beam Destruction WPRO-304-OG	**Pre-Demonstration** Development work with the compounds of interest at the bench scale needs to be done to justify scale-up testing.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
	Steam Stripping WPRO-221-OG	**Demonstration** This is an accepted industrial process that can remove volatile organics with >99+% efficiency especially from contaminated aqueous streams. The application of the process to satisfactorily remove hazardous and radioactive species needs to be demonstrated.	Demonstrate the effectiveness of the technology to meet the site requirements.	The RD&D effort is estimated to require $ 1-2 million to meet site specific needs.
	Flameless Thermal Oxidizers WPRO-305-OG	**Demonstration** Development work with the compounds of interest at the bench scale needs to be done to justify scale-up testing.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-1.5 million.
Physical Treatment	Low Temperature Separation WPRO-220-OG	**Pre-Demonstration** This is an accepted industrial process for the separation of low-boiling components from high-boiling components. The process can achieve separation efficiencies greater than 99%.	Further RD&D on the process is needed to develop the optimum processing conditions.	The RD&D effort is estimated to require $ 1-2 million to meet site specific needs.

Technology Logic

Waste Manageme

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternative
Waste Off-Gases from D&D, RA, and WM Operations (cont.)	Non-Volatile Organics in Gases	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physical Treatment (cont.)
				Chemical Treatment
				Thermal Treatment

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Treatment (cont.)	Inorganic Membrane Separation WPRO-300-OG	**Pre-Demonstration** The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.5-2 million to further develop the process to meet the site needs.
	Filtration WPRO-201-OG	**Demonstration** This is an accepted process for separating solids from fluids. The process can achieve removal efficiencies greater than 99%. The use of the process to meet the site requirements will however, need to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Scrubbers WPRO-301-OG	**Demonstration** Scrubbers are comercially available though need to be demonstrated for particular applications at K-25.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
Chemical Treatment	Solvent Scrubbing WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
Thermal Treatment	Incineration WPRO-108-OG	**Accepted** The EPA considers incineration to be the best demonstrated available technology (BDAT) for the destruction of organics. Incineration can achieve DREs greater than 99.999% for certain organics. However, additional RD&D on several aspects of incineration is still required.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application, funding, and regulatory approval.
	Catalytic Destruction WPRO-109-OG	**Pre-Demonstration** The EPA considers incineration to be the best demonstrated available technology (BDAT) for the destruction of organics. Incineration can achieve DREs greater than 99.999% for certain organics. However, additional RD&D on several aspects of incineration is still required.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.

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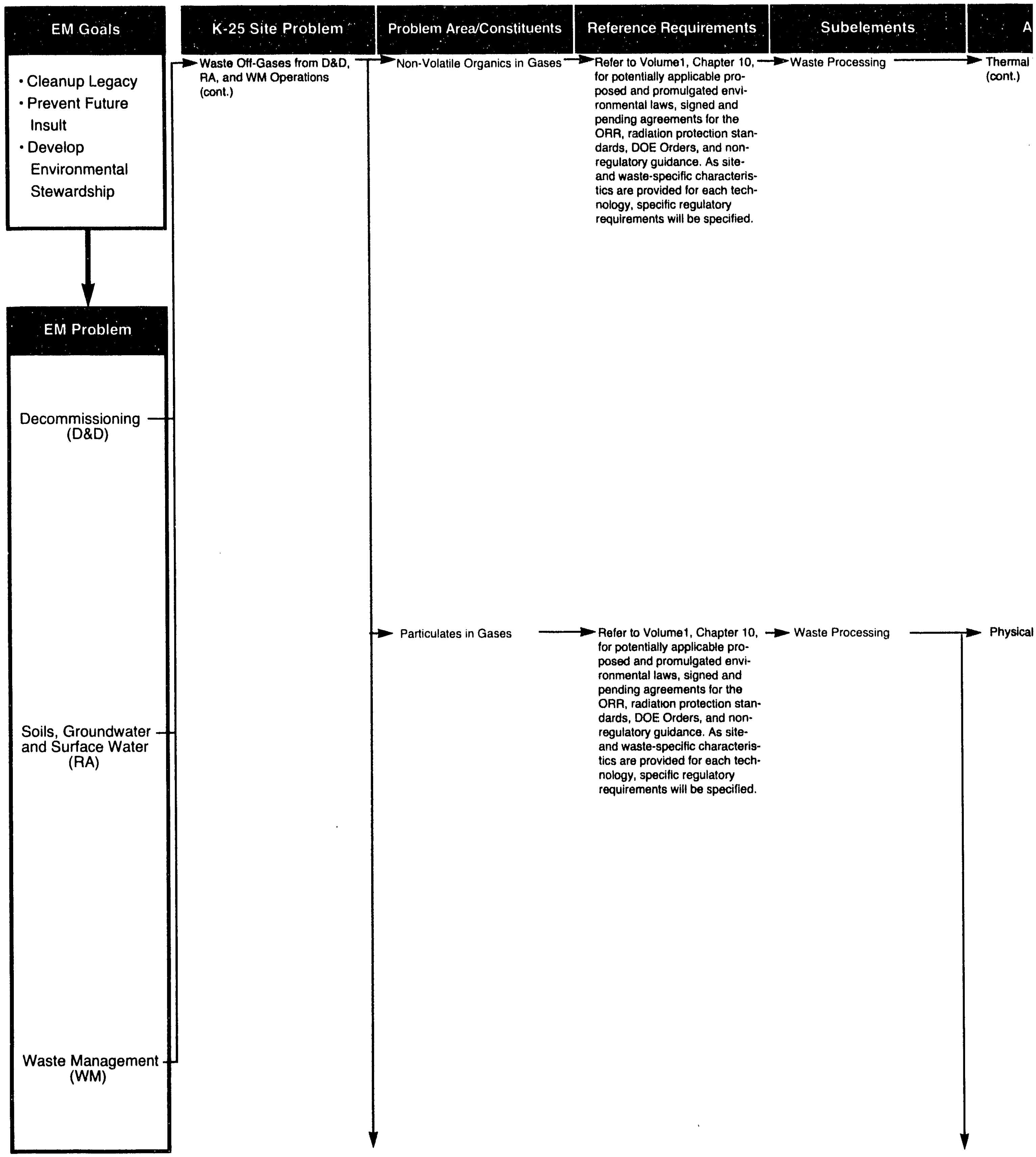

Logic Diagram
Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Thermal Treatment (cont.)	Molten Salt Oxidation WPRO-113-OG	**Demonstration** This is not a new process however, its application for treating hazardous and radioactive contaminants has not been demonstrated. One advantage of the process is that the process and equipment is transportable (as opposed to a fixed treatment facility) and can be located near the waste site. The process should be capable of destroying organics with a >99% efficienc. Additional RD&D is required to fully develop the process to treat mixed wastes.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.4 million for a 3 year development effort.
	Electron Beam Destruction WPRO-304-OG	**Pre-Demonstration** Development work with the compounds of interest at the bench scale needs to be done to justify scale-up testing.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 0.75-1.5 million.
	Steam Stripping WPRO-221-OG	**Demonstration** This is an accepted industrial process that can remove volatile organics with >99+% efficiency especially from contaminated aqueous streams. The application of the process to satisfactorily remove hazardous and radioactive species needs to be demonstrated.	Demonstrate the effectiveness of the technology to meet the site requirements.	The RD&D effort is estimated to require $ 1-2 million to meet site specific needs.
	Flameless Thermal Oxidizers WPRO-305-OG	**Demonstration** Development work with the compounds of interest at the bench scale needs to be done to justify scale-up testing.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-1.5 million.
Physical Treatment	Inorganic Membrane Separation WPRO-300-OG	**Pre-Demonstration** The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.5-2 million to further develop the process to meet the site needs.
	Adsorption WPRO-202/203-OG	**Demonstration** Laboratory studies indicate removal efficiencies greater than 90% for the removal of radioactive species using various adsorbing media. Further development is necessary to develop more effective adsorption media for the treatment of mixed waste contaminated liquids. Development would include for example, scale-up studies, development of high surface area and appropriate particle size media for continuous operations, and the development of appropriate media for the removal of various contaminants.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.

Technology Logic

Waste Manageme

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternativ
Waste Off-Gases from D&D, RA, and WM Operations (cont.)	Particulates in Gases (cont.)	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physical Treatment (cont.)
				Chemical Treatment

Logic Diagram

Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Treatment (cont.)	Filtration WPRO-201-OG	**Demonstration** This is an accepted process for separating solids from fluids. The process can achieve removal efficiencies greater than 99%. The use of the process to meet the site requirements will however, need to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Scrubbers WPRO-301-OG	**Demonstration** Scrubbers are comercially available though need to be demonstrated for particular applications at K-25.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
	Cyclone Separation WPRO-302-OG	**Evolving Technology** Application of commercially available cyclones to specific K-25 problems must be investigated before full-scale use	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	HGMS WPRO- 204-OG	**Demonstration** The treatment is commercially available for example, for the removal of trace impurities from kaolin clays. Removal efficiencies for the process are greater than 99%. However, its use to treat mixed waste contaminated fluids needs additional RD&D.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to be $ 0.5-1 million.
Chemical Treatment	Solvent Scrubbing WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.

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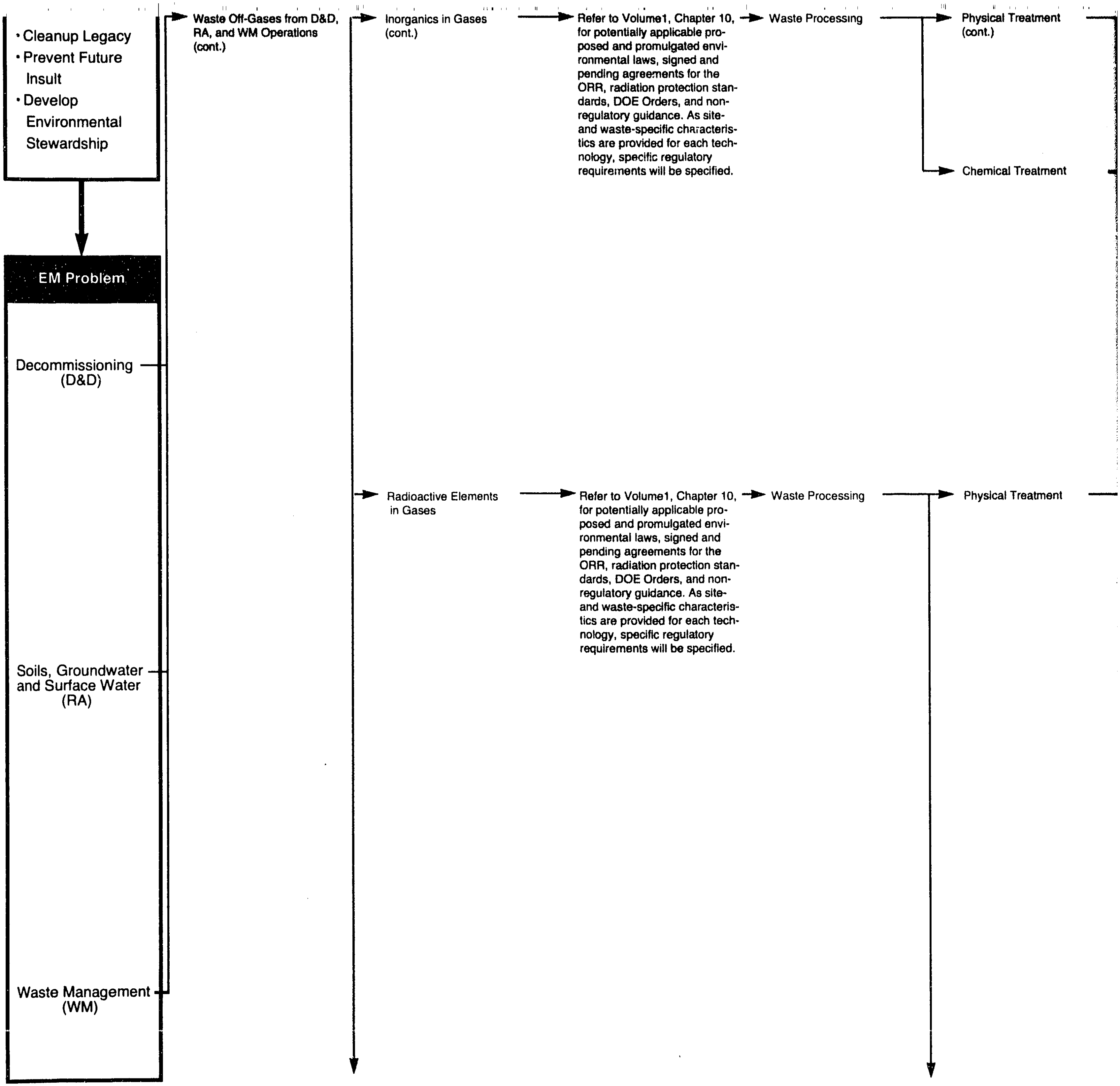
EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Al
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Waste Off-Gases from D&D, RA, and WM Operations (cont.)	Particulates in Gases (cont.)	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Thermal T
		Inorganics in Gases	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physical T

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Thermal Treatment	Molten Salt Oxidation WPRO-113-OG	**Demonstration** This is not a new process however, its application for treating hazardous and radioactive contaminants has not been demonstrated. One advantage of the process is that the process and equipment is transportable (as opposed to a fixed treatment facility) and can be located near the waste site. The process should be capable of destroying organics with a >99% efficienc. Additional RD&D is required to fully develop the process to treat mixed wastes.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.4 million for a 3 year development effort.
Physical Treatment	Inorganic Membrane Separation WPRO-300-OG	**Pre-Demonstration** The RD&D effort to develop inorganic microporous filters is estimated to require $ 0.75-1 million. The payback is estimated to be $20-25 million based on significantly reduced waste disposal costs.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.5-2 million to further develop the process to meet the site needs.
	Adsoprtion WPRO-202/203-OG	**Pre-Demonstration** Laboratory studies indicate removal efficiencies greater than 90% for the removal of radioactive species using various adsorbing media. Further development is necessary to develop more effective adsorption media for the treatment of mixed waste contaminated liquids. Development would include for example, scale-up studies, development of high surface area and appropriate particle size media for continuous operations, and the development of appropriate media for the removal of various contaminants.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
	Filtration WPRO-201-OG	**Demonstration** This is an accepted process for separating solids from fluids. The process can achieve removal efficiencies greater than 99%. The use of the process to meet the site requirements will however, need to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.
	Scrubbers WPRO-301-OG	**Demonstration** Scrubbers are comercially available though need to be demonstrated for particular applications at K-25.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
	Cyclone Separation WPRO-302-OG	**Demonstration** Application of commercially available cyclones to specific K-25 problems must be investigated before full-scale use	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.



• Cleanup Legacy
• Prevent Future Insult
• Develop Environmental Stewardship
EM Problem
Decommissioning (D&D)
Soils, Groundwater and Surface Water (RA)
Waste Management (WM)
Waste Off-Gases from D&D, RA, and WM Operations (cont.)
Inorganics in Gases (cont.)
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Waste Processing
Physical Treatment (cont.)
Chemical Treatment
Radioactive Elements in Gases
Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.
Waste Processing
Physical Treatment

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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Physical Treatment (cont.)	HGMS WPRO-204-OG	**Demonstration** The treatment is commercially available for example, for the removal of trace impurities from kaolin clays. Removal efficiencies for the process are greater than 99%. However, its use to treat mixed waste contaminated fluids needs additional RD&D.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to be $ 0.5-1 million.
Chemical Treatment	Solvent Scrubbing WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
Physical Treatment	Scrubbers WPRO-301-OG	**Demonstration** Scrubbers are comercially available though need to be demonstrated for particular applications at K-25.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
	Adsorption WPRO-202/203-OG	**Pre-Demonstration** Laboratory studies indicate removal efficiencies greater than 90% for the removal of radioactive species using various adsorbing media. Further development is necessary to develop more effective adsorption media for the treatment of mixed waste contaminated liquids. Development would include for example, scale-up studies, development of high surface area and appropriate particle size media for continuous operations, and the development of appropriate media for the removal of various contaminants.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1.25 million.
	Filtration WPRO-201-OG	**Demonstration** This is an accepted process for separating solids from fluids. The process can achieve removal efficiencies greater than 99%. The use of the process to meet the site requirements will however, need to be demonstrated.	The use of the technology to meet the site requirements needs to be demonstrated.	Demonstration costs are estimated to require up to $ 1 million.

Technology Log

Waste Manag

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Al
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Waste Off-Gases from D&D, RA, and WM Operations (cont.)	Radioactive Elements in Gases	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Chemical
	Waste Gases of Unknown Characteristics from D&D and RA Operations (some possibly in cylinders of uncertain integrity)	Orphan Gas Cylinders with No Information on Cylinder Contents	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Physical

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram
Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Chemical Treatment	Solvent Scrubbing WPRO-211/212-OG	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.
	Ion Exchange WPRO-217/218-OG	**Demonstration** This is one of the accepted methods used in industry for treating liquids. Treatment efficiencies can be greater than 99% depending upon the application, the ion exchange media, and the solutes to be removed.	The use of the technology to meet the site requirements needs to be demonstrated.	Development costs are estimated to be $ 1.25 million.
	Bucky Ball Chemistry WPRO-101-OG	**Evolving Technology** This is a novel technology that has many potential applications in fields such as mixed wastes treatment, nuclear medicine, tribology, and material science. Conceptually, the technology is sophisticated (uses lasers) and yet simple. For mixed wastes treatment, the process would essentially encapsulate the radioactive and hazardous metals at the elemental level in high molecular weight carbon cages (called fullerenes) thereby isolating them from the environment.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort to develop the technology is estimated to require $ 10 million. The payback is estimated to be in the range of $ 150 million considering savings in waste treatment and disposal costs and potential spinoffs in other fields such as nuclear medicine and new materials.
Physical Treatment	Recharacterize WPR-303-OG	**Accepted**	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.
	Repackage WPRO-303-OG	**Accepted**	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated.	Knowledge of process application(s) and funding.

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EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
Waste Gases of Unknown Characteristics from D&D and RA Operations (some possibly in cylinders of uncertain integrity)	Orphan Gas Cylinders with No Information on Cylinder Contents (cont.)	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidan As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Processing	Chemical

Logic Diagram
ˌlanagement

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
→ Chemical Treatment →	Solvent Scrubbing WPRO-211/212-OG →	**Demonstration** Continuous solvent extraction in counter-current contactors (e.g., centrifugal contactors) is demonstrated technology for the separation of heavy metals or organics from aqueous or organic solutions. Centrifugal contactor based processes for the separation and recovery of radionuclides has been technology at DOE nuclear processing sites for over 25 years. The technology can be applied to treat and recover a wide range of contaminant concentrations. The advantages of the centrifugal contactor based extraction process are its relatively small size, small hold-up volume, and rapid start-up characteristics. This technology when used with other waste treatment processes would enhance the overall waste treatment strategy. However, the use of the technology for the treatment of solid wastes requires additional RD&D. →	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment. →	The RD&D effort is estimated to require $ 1-2.5 million. The payback could be significant.

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Waste Managem

EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternat
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Contaminated Solid Wastes	Contaminated Concrete Rubble Scrap Transite Scrap Asbestos Pipe & Insulation Other Scrap Bldg.Materials Scrap Porous Nickel Scrap Aluminum, Copper, and Other Non-Ferrous Metals (Other than Nickel) Scrap Steel Scrap Plastic, Paper, and Cloth Contaminated Clothing and Rags Waste UO_2F_2 Spent Ion Exchange Media Waste Processing Residuals	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Stabilization	Solidification Macroencapsulat Microencapsulati Chemical Fixatio

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

Logic Diagram
Management

Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
Solidification Macroencapsulation Microencapsulation Chemical Fixation	Cementitious Materials WSTA-100-OG	**Accepted** This is an accepted method for stabilizing hazardous and low-level radioactive wastes for disposal. However, the technology (as currently practiced) is more art than science. This method generally results in a 0.5 to 2-fold increase in the volume of the final wasteform for disposal.	Though an accepted technology, the use of the technology to meet the site requirements needs to be demonstrated. Also, need to develop better understanding of the immobilization chemistry and mechanisms.	Knowledge of process application, funding, and regulatory approval. In general cementitious stabilization/solidification costs range between $ 50 to $ 500 per cubic foot of waste. These costs are very dependent upon the wastes being solidified, the cementitious materials being employed, and the performance criteria for the wasteform.
	Polymer Impregnated Concrete WSTA-101-OG	**Evolving Technology** This is a developmental technology that is developing an alternate wasteform that is less leachable (and thus more acceptable) than cementitious wasteforms. The polymer addition serves to waterproof the final wasteform thus reducing the migration of the immobilized contaminants into the environment. This method is also expected to result in a one to two-fold increase in the final wasteform volume for disposal.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 5-10 million. The payback could be significant.
	Plastics–Thermoplastics WSTA-102/103-OG	**Pre-Demonstration** The bitumen stabilization process is determined to be at the demonstration level while the polyethylene process is determined to be at the pre-demonstration level of development. Depending upon the wastes being stabilized, thermoplastic stabilization processes result in a net decrease in the final wasteform volume. The technology is not mature and additional research, development, and demonstration (RD&D) is needed to further develop the technology and its acceptability as a stabilization method by the regulators.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.
	Plastics–Thermosetting WSTA-104-OG	**Pre-Demonstration** This process is especially suitable for stabilizing spent ion exchange resin beds for disposal. The process does not require high temperatures or dried wastes and normally results in no net increase in the volume of the final wasteform. However, if the method is used to stabilize a net increase in the volume of the final wasteform could result. Additional RD&D on the process could help increase its applicability to stabilizing other wastes.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 2-5 million. The payback could be significant.

Technology Log[ic Diagram]

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EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

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K-25 Site Problem

Contaminated Solid Wastes

Problem Area/Constituents

Contaminated Concrete Rubble

Scrap Transite

Scrap Asbestos Pipe & Insulation

Other Scrap Bldg.Materials

Scrap Porous Nickel

Scrap Aluminum, Copper, and Other Non-Ferrous Metals (Other than Nickel)

Scrap Steel

Scrap Plastic, Paper, and Cloth Contaminated Clothing and Rags

Waste UO_2F_2

Spent Ion Exchange Media

Waste Processing Residuals

Reference Requirements

Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.

Subelements

Waste Stabilization

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Solidificat[...] (cont.)

Macroenc[...] (cont.)

Microenc[...] (cont.)

Chemical[...] (cont.)

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Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
➢ Solidification (cont.) ➢ Macroencapsulation (cont.) ➢ Microencapsulation (cont.) ➢ Chemical Fixation (cont.)	High-Temperature Crystalline Materials WSTA-105-OG	**Evolving Technology** This is a developmental technology which uses high temperatures to immobilize the wastes in a ceramic wasteform. These wasteforms are generally inert and exhibit very low leachability characteristics. Depending upon the waste characteristics ceramic wasteforms can result in a significant decrease in the volume of the final wasteform which can translate into significant savings in waste disposal costs.	Further research, development, and demonstration (RD&D) on the process to develop the technology to deployment.	The RD&D effort is estimated to require $ 5-10 million. The payback could be significant.
	High-Temperature Noncrystalline Materials WSTA-106-OG	**Pre-Demonstration** This is an accepted process for the disposal of high-level nuclear wastes however, its suitability for the disposal of hazardous and low-level radioactive wastes needs to be established. Because of the high processing temperatures, this process results in the decrease of the final wasteform volume. Under normal environmental conditions the final wasteform is inert and nonleachable.	Demonstrate the effectiveness of the technology to meet the site requirements.	The RD&D effort is estimated to require $ 5-10 million. The payback could be significant.

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- Cleanup Legacy
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- Decommissioning (D&D)
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- Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
Radioactive & Hazardous Material Shipments	Limited Quantities of radioactive materials that are accepted quantities.	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Packaging, Handling, & Transportation (WPHT)	Strong Tl
	Non-fissile concentrated wastes having total activities less than Type A package limits.	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Packaging, Handling, & Transportation (WPHT)	Multi-use
	Non-fissile concentrated wastes having total activities less than Type A package limits.	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Packaging, Handling, & Transportation (WPHT)	Light We
	Fissile Wastes	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Packaging, Handling, & Transportation (WPHT)	Light We
	PCB Contaminated Wastes	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Packaging, Handling, & Transportation (WPHT)	POP Con.

→ Strong Tight Containers →	Accepted Packages WPHT- 100-OG →	**Accepted** →	New package designs may be required. →	None
→ Multi-use Containers →	Multi-use, standardized Type A Packaging WPHT- 101-OG →	**Evolving Technology** →	New standardized Type A package designs need to be developed and qualified to meet regulations. Designs must be user friendly and available to a wide variety of users. An operationally efficient multi-use Type A package, or packages, for radioactive materials needs to be developed. →	Funding requirements for R&D are estimated to be $1 million.
→ Light Weight Containers →	Type B Packaging WPHT-102-OG →	**Accepted** →	New package designs and certifications may be required. Certified package design can be identified from RAMPAC database and Packaging management Transportation System (PMTS) database which will identify numbers and status of packagings available under development by EM-5621. →	None
→ Light Weight Containers →	Type A Fissile Certified Packaging Type B Fissile Certified Packaging WPHT-103-OG →	**Accepted** →	New package designs and certifications may be required. Certified package design can be identified from RAMPAC database and Packaging management Transportation System (PMTS) database which will identify numbers and status of packagings available under development by EM-5621. →	None
→ POP Container →	Performance Oriented Packaging (POP) WPHT-104-OG →	**Accepted** →	New package designs may be required. →	None

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Waste Packaging, Handling, and Transportation (WPH&T)	Asbestos	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Packaging, Handling, & Transportation (WPHT)	POP Co
		Non-radioactive Hazardous Waste	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Packaging, Handling, & Transportation (WPHT)	POP Co
		Onsite Packaging	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Packaging, Handling, & Transportation (WPHT)	On-site P
		Poor definition of Waste Packaging, Handling, & Transportation Requirements for Users	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Packaging, Handling, & Transportation (WPHT)	Define In

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram
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A	Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
or	POP Container	Performance Oriented Packaging (POP) Group II and III WPHT- 105-OG	**Accepted**	New package designs may be required.	None
or	POP Container	Borehole Disposal Performance Oriented Packaging (POP) Group I, II, III WPHT- 106-OG	**Accepted**	New package designs may be required.	None
e F	On-site Packaging	Type A, Type B, Fissile, Strong Tight, IP, POP, and Bulk packaging or packaging equivalent in safety. WPHT-107-OG	**Accepted**	New package designs may be required.	None
In	Define Interfaces	User Interface WPHT-108-OG	**Conceptual** Interface working groups need to be formed.	None	Implementation cost estimated at $1M in 1992 dollars.

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Waste Management

EM Goals

- Cleanup Legacy
- Prevent Future Insult
- Develop Environmental Stewardship

EM Problem

Decommissioning (D&D)

Soils, Groundwater and Surface Water (RA)

Waste Management (WM)

K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternatives
Disposal of final residues from D&D, ER, and WM operations	Clean Debris	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Disposal	Landfill
	Scrap Asbestos	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Disposal	Landfill
	Low-Level Rad Waste	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Disposal	Trench Disposal

Logic Diagram
Management

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
→ Landfill	→ Y-12 Plant Industrial Landfill Tennessee WDIS-101-OG	→ **Accepted** This landfill is expected to be operational in July 1993. The landfill has a design capacity of 1.5 million cubic feet and a design life of 43 years.	→ None	→ Need regulatory approval and funding The wastes disposed in this landfill must meet the waste acceptance criteria (WAC) for the landfill and obtain approval from the facility manager for the disposal of the wastes. Funding would be required for performing waste analyses (to ensure compliance with the landfill WAC) and waste packaging, handling, and transportation (WPH&T) to the landfill. Estimated funding requirements cannot be forecast because they are dependent upon several factors such as waste volumes, tipping fees, analytical requirements, and WPH&T costs.
→ Landfill	→ Y-12 Plant Industrial Landfill Tennessee WDIS-101-OG	→ **Accepted** This landfill is expected to be operational in July 1993. The landfill has a design capacity of 1.5 million cubic feet and a design life of 43 years.	→ None	→ Need regulatory approval and funding The wastes disposed in this landfill must meet the waste acceptance criteria (WAC) for the landfill and obtain approval from the facility manager for the disposal of the wastes. Funding would be required for performing waste analyses (to ensure compliance with the landfill WAC) and waste packaging, handling, and transportation (WPH&T) to the landfill. Estimated funding requirements cannot be forecast because they are dependent upon several factors such as waste volumes, tipping fees, analytical requirements, and WPH&T costs.
→ Trench Disposal	→ Nevada Test Site WDIS-102-OG	→ **Accepted** This facility has been earmarked as one of the facilities for the disposal of DOE low-level radioactive (rad) wastes.	→ None	→ Need regulatory approval and funding The wastes disposed in this landfill must meet the waste acceptance criteria (WAC) for the landfill and obtain approval from the facility manager for the disposal of the wastes. Funding would be required for performing waste analyses (to ensure compliance with the landfill WAC) and waste packaging, handling, and transportation (WPH&T) to the landfill. Estimated funding requirements cannot be forecast because they are dependent upon several factors such as waste volumes, tipping fees, analytical requirements, and WPH&T costs.

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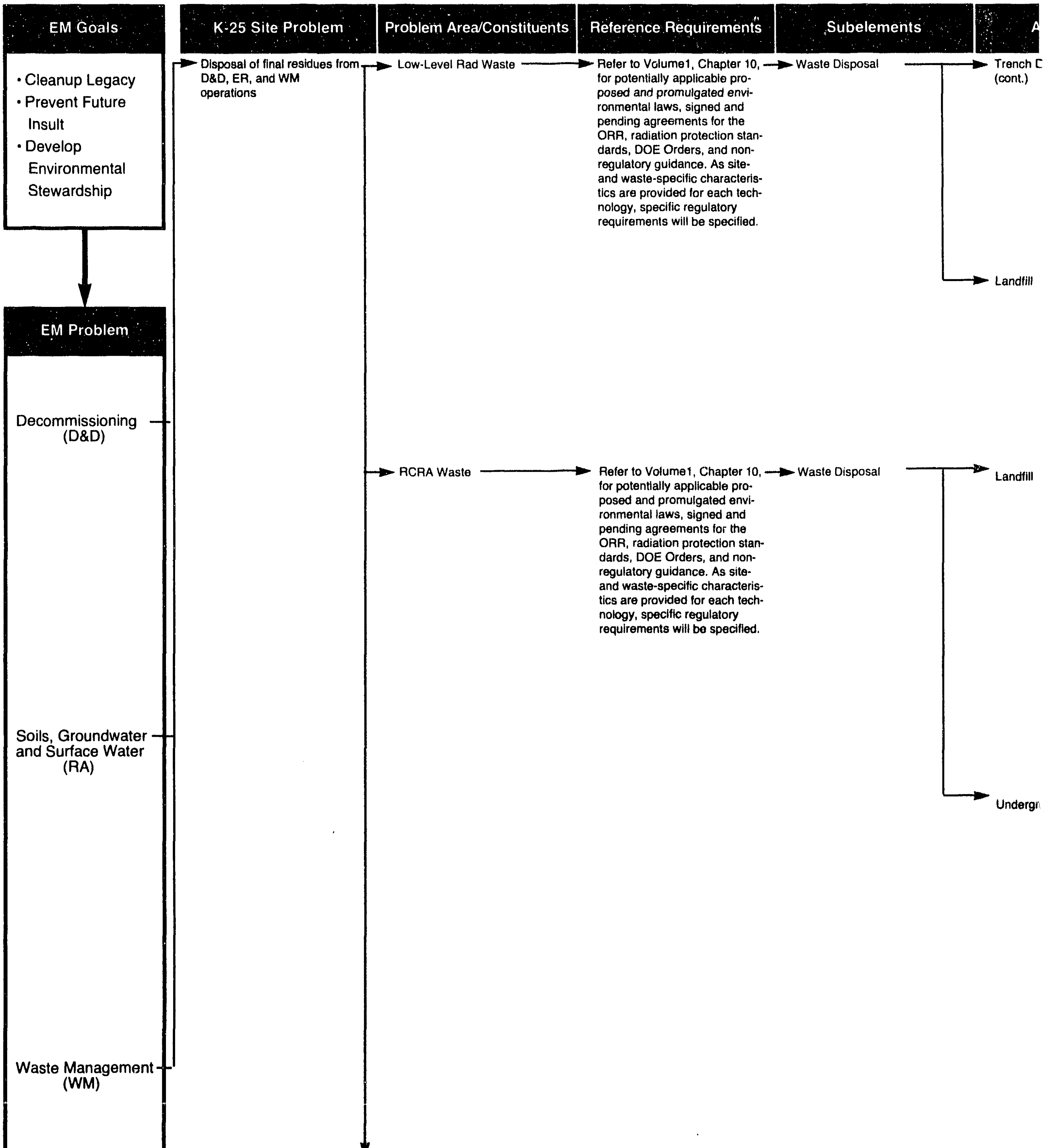

Logic Diagram
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Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
Trench Disposal (cont.)	Borehole Disposal WDIS-106-OG	**Pre-demonstration** This is a developmental disposal option that has been endorsed by the International Atomic Energy Agency (IAEA) for the disposal of radioactive wastes. The site for the facility would be determined after evaluating the geohydrology and the resulting environmental impacts of potential sites. One potential site is the Conasauga shale formation that underlies parts of East Tennessee.	Additional research, development, and demonstration (RD&D) is required on the method to determine its environmental, economic, and engineering acceptability. This RD&D effort would include for example, identifying candidate disposal sites, the characteristics of the wastes to be disposed in the boreholes, and evaluating the geohydrology of the sites.	Estimated RD&D cost is $2-3 million (1992 dollars)
Landfill	ORR Class I Low-Level Waste Landfill WDIS-106-OG	**Pre-demonstration** West Chestnut Ridge at Y-12 Plant	Research, development, and demonstration (RD&D) needs to be conducted to determine the environmental acceptability of this disposal option for the low-level radioactive wastes.	Need regulatory approval and funding The facility is projected to be ready to accept wastes in early 1999. The capital cost for the facility is estimated to be $ 90 million (1992 dollars) and the annual operating costs are estimated to be around $ 8 million (1992 dollars).
Landfill	Approved commercial landfills for RCRA wastes (e.g., Chemical Waste Management at Emelle, AL, Envirocare in UT, or U. S. Ecology landfill in NV).	**Accepted** The strictly Resource Conservation and Recovery Act (RCRA) solid wastes from the site will be disposed of in approved commercial landfills provided the wastes meet the landfill's waste acceptance criteria and it is economic.	None	Need regulatory approval and funding The wastes disposed in this landfill must meet the waste acceptance criteria (WAC) for the landfill and obtain approval from the facility manager for the disposal of the wastes. Funding would be required for performing waste analyses (to ensure compliance with the landfill WAC) and waste packaging, handling, and transportation (WPH&T) to the landfill. Estimated funding requirements cannot be forecast because they are dependent upon several factors such as waste volumes, tipping fees, analytical requirements, and WPH&T costs.
Underground Disposal	Borehole Disposal WDIS-100-OG	**Pre-demonstration** This is a developmental disposal option that has been endorsed by the International Atomic Energy Agency (IAEA) for the disposal of radioactive wastes. The site for the facility would be determined after evaluating the geohydrology and the resulting environmental impacts of potential sites. One potential site is the Conasauga shale formation that underlies parts of East Tennessee.	Additional research, development, and demonstration (RD&D) is required on the method to determine its environmental, economic, and engineering acceptability. This RD&D effort would include for example, identifying candidate disposal sites, the characteristics of the wastes to be disposed in the boreholes, and evaluating the geohydrology of the sites.	Estimated RD&D cost is $2-3 million (1992 dollars)

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	A[...]
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	→ Disposal of final residues from D&D, ER, and WM operations	→ Low-Level Mixed Waste →	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	→ Waste Disposal	→ Landfill → Undergr[...]
		→ TRU Waste →	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and nonregulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	→ Waste Disposal	→ Undergr[...] Retrieva[...]

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram
Management

Alternatives	Technologies	Status	Science/ Technology Needs	Implementation Needs
→ Landfill →	Envirocare, UT Landfill WDIS-104-OG →	**Accepted** →	None →	Need regulatory approval and funding The wastes disposed in this landfill must meet the waste acceptance criteria (WAC) for the landfill and obtain approval from the facility manager for the disposal of the wastes. Funding would be required for performing waste analyses (to ensure compliance with the landfill WAC) and waste packaging, handling, and transportation (WPH&T) to the landfill. Estimated funding requirements cannot be forecast because they are dependent upon several factors such as waste volumes, tipping fees, analytical requirements, and WPH&T costs.
→ Underground Disposal →	Borehole Disposal WDIS-100-OG →	**Pre-demonstration** → This is a developmental disposal option that has been endorsed by the International Atomic Energy Agency (IAEA) for the disposal of radioactive wastes. The site for the facility would be determined after evaluating the geohydrology and the resulting environmental impacts of potential sites. One potential site is the Conasauga shale formation that underlies parts of East Tennessee.	Additional research, development, and demonstration (RD&D) is required on the method to determine its environmental, economic, and engineering acceptability. This RD&D effort would include for example, identifying candidate disposal sites, the characteristics of the wastes to be disposed in the boreholes, and evaluating the geohydrology of the sites. →	Estimated RD&D cost is $2-3 million (1992 dollars)
→ Underground Waste Retrievable Facilities →	Waste Isolation Pilot Plant (WIPP), New Mexico WDIS-105-OG →	**Demonstration** → This facility has been designation by DOE for the disposal transuranic (TRU) wastes.	Additional research and evaluations need to be performed to obtain regulatory approval to dispose TRU wastes at the site. →	Need regulatory approval for TRU waste disposal and funding Funding would be required for performing waste analyses and WPH&T to ensure compliance with the WIPP waste acceptance criteria. The estimated funding requirements cannot be forecast because they are dependent upon several factors such as waste vclumes, analytical requirements, WPH&T, and disposal costs.

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EM Goals	K-25 Site Problem	Problem Area/Constituents	Reference Requirements	Subelements	Alternativ
• Cleanup Legacy • Prevent Future Insult • Develop Environmental Stewardship	Minimize the generation of hazardous and mixed wastes.	• Solvents • RAD • PCB • Organices • Inorganics • Metals • Wood • Plastics • Cloth • Paper • Asbestos	Refer to Volume1, Chapter 10, for potentially applicable proposed and promulgated environmental laws, signed and pending agreements for the ORR, radiation protection standards, DOE Orders, and non-regulatory guidance. As site- and waste-specific characteristics are provided for each technology, specific regulatory requirements will be specified.	Waste Minimization	• Minimize the creati wastes. • Characterize and s the wastes as early i ation as possible to i hazardous waste ge • Maximize the use c ardous substitutes. • Transfer potential v rials (e.g. specialty fr other DOE plants ha need for the material • Seek opportunities taminated spent mat other DOE applicatic contaminated metal (supercollider) • Maximize the recyc ed spent materials • Sell maximum matc scrap as legally perr • Establish acceptab Regulatory Concern ("de-minimus" values. • **Think Waste Minim** Waste Minimization E System (WMES)

EM Problem

- Decommissioning (D&D)
- Soils, Groundwater and Surface Water (RA)
- Waste Management (WM)

Logic Diagram
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Alternatives	Technologies	Status	Science/Technology Needs	Implementation Needs
• Minimize the creation of wastes. • Characterize and segregate the wastes as early in the operation as possible to minimize hazardous waste generation • Maximize the use of non-hazardous substitutes. • Transfer potential waste materials (e.g. specialty freons) to other DOE plants having a need for the material • Seek opportunities to use contaminated spent materials in other DOE applications (e.g. contaminated metal for use in supercollider) • Maximize the recycle of treated spent materials • Sell maximum materials as scrap as legally permitted. • Establish acceptable Below Regulatory Concern (BRC) and "de-minimus" values. • **Think** Waste Minimization!		**Demonstration**	The science and technology needs are expected to be minimal because incorporating the waste minimization ethic will not require new technology but a change in operating philosophy, attitudes and behavior.	General implementation needs include inculcating the waste minimization philosophy among site personnel through education and establishing acceptable BRC and de-minimus values for radioactive contamination levels in potential wastes so that significant quantities of potential waste materials can either be recycled, sold as scrap, or disposed at lower costs.
Waste Minimization Evaluation System (WMES)	Computer Software WMIN-100-OG	**Demonstration** A prototype software program was used to analyze waste minimization at a solvent degreasing operation at the Y-12 Plant. This application showed areas where the degreasing operations could be improved from a waste minimization perspective.	Develop and demonstrate the effectiveness of the WMES to minimize site wastes and waste disposal costs. The science/technology needs include for example, software development (e.g., programing and process simulation) and expertise capture.	Development and demonstration of the WMES is estimated to require $ 3-5 million. The savings from implementing the system could be substantial.

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Internal

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