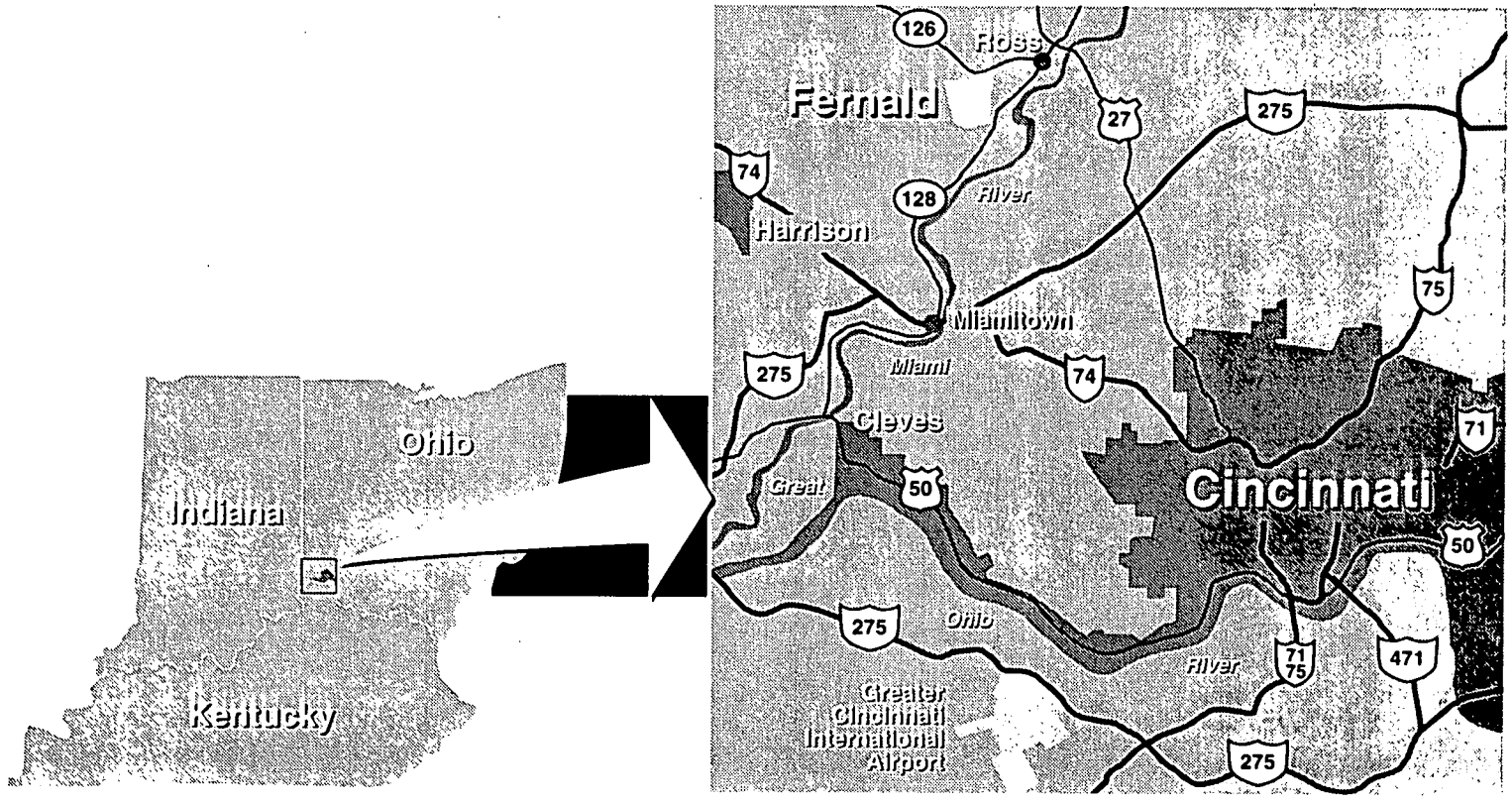
DOE PUBLIC WORKSHOP
SILO 3 PATH FORWARD
JULY 1, 1997

6:00 p.m.	Welcome/Opening Remarks	Nina Akgunduz
6:10 p.m.	Review of Proposed Technologies to be carried forward for Silo 3 Remediation	Don Paine
6:20 p.m.	Education Process of Potential Technologies Available for Silo 3 Remediation	Don Paine
7:00 p.m.	Comparative Analysis of Potential Technologies Available For Silo 3 Remediation	Terry Hagen
7:30 p.m.	Informal Question and Answer Session	
8:00 p.m.	Review of Action Items/ Closing Remarks	Nina Akgunduz

FERNALD AND VICINITY



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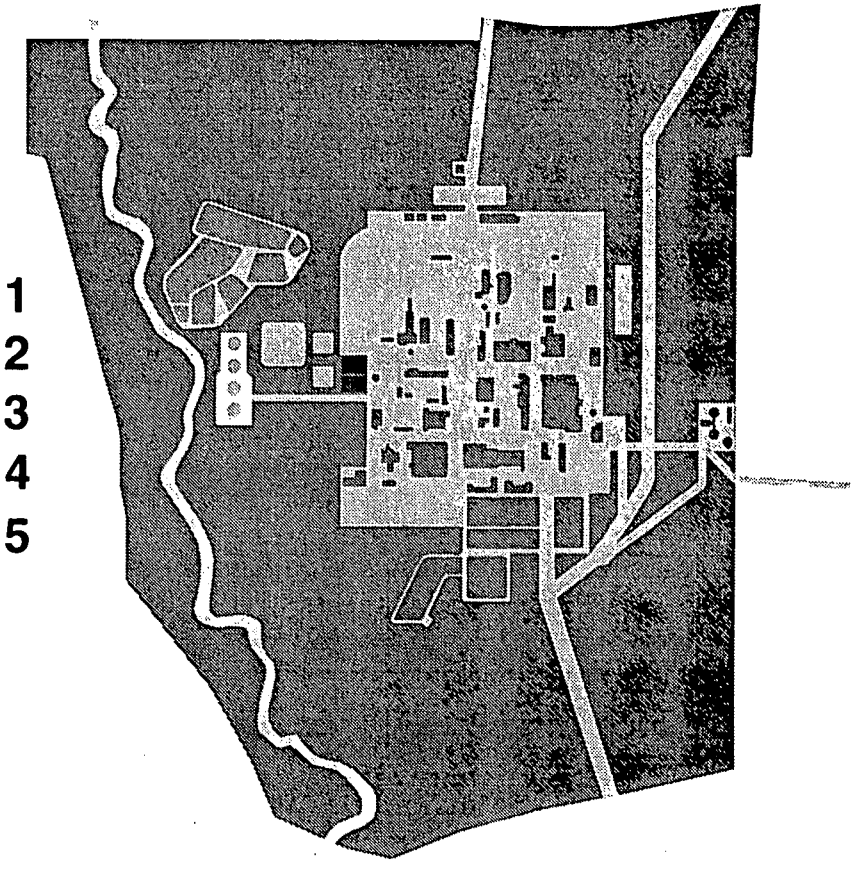
OPERABLE UNITS

FERNALD

- Operable Unit 1
- Operable Unit 2
- Operable Unit 3
- Operable Unit 4
- Operable Unit 5



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OPERABLE UNIT 4

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- Operable Unit 4 (OU4) is one of five operable units at the FEMP
- OU4 consists of:
  - Four concrete storage silos and their contents
  - Decant sump tank
  - Radon treatment system
  - Earthen berm surrounding Silos 1 and 2
  - Soils within OU4 boundary
- Silos 1 and 2 contain K-65 residues
- Silos 3 contains "cold" metal oxides
- Silo 4 is empty
- Decant sump tank contains water and sludge from the K-65 residues

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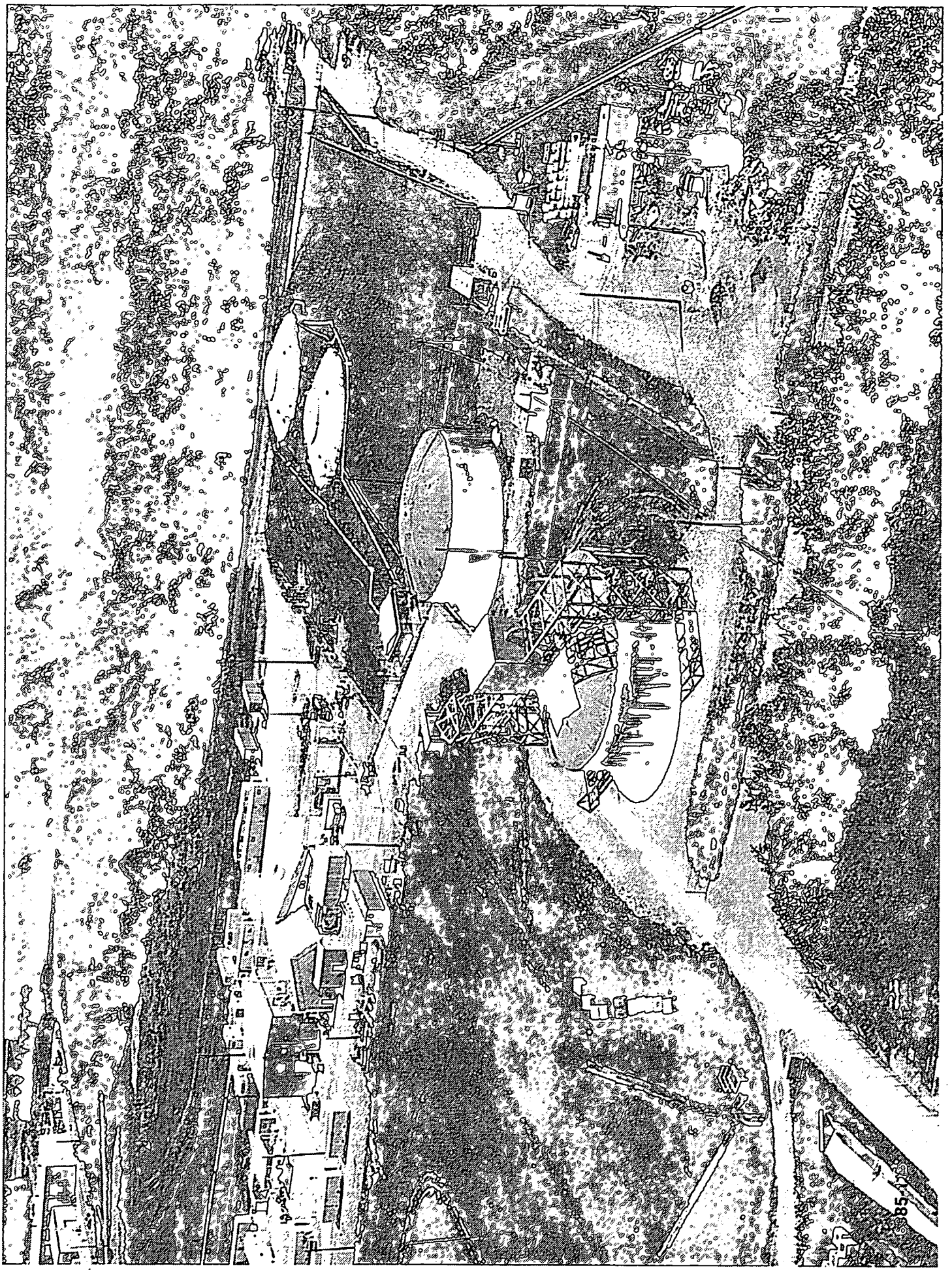

K-65 CHARACTERISTICS

FERNALD

- Wet gray-silty solid
- Contains elevated concentrations of radium, thorium, and lead-210
- Radon emanation rate is approximately 4500 pCi/m2/s
    - Greater than 200 times EPA limit (20 pCi/m2/s)
- Elevated concentrations of inorganics
    - Barium and Lead

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SILO 3 CHARACTERISTICS

FERNALD

- Dry powdery solid
- Mixture of metal oxides
- Much lower concentration of radionuclides
- Predominant radionuclides
  - Thorium
  - Uranium
  - Lead-210
- Leaches arsenic, chromium, cadmium, and selenium at rates exceeding RCRA limits
- Total volume of Silo 3 material - 5088 yd3
- Total volume of waste in Silos for disposal - 13978 yd3 (19365 tons)

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CERCLA "NINE CRITERIA"

TRESHHOLD CRITERIA

Overall Protection of Human Health and the Environment
Compliance with ARARs

BALANCING CRITERIA

Long-Term Effectiveness and Permanence
Reduction of Toxicity, Mobility, or Volume through Treatment
Implementability
Short-Term Effectiveness
Cost

MODIFYING CRITERIA

State Acceptance
Community Acceptance

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THRESHOLD CRITERIA

OVERALL PROTECTION OF HUMAN HEALTH AND ENVIRONMENT

- All four alternatives are protective of human health and the environment
  - Transportation risk addressed through a combination of treatment and containerization
  - Long-term risks addressed through combination of treatment and arid, impacted disposal environment

COMPLIANCE WITH APPLICABLE OR RELEVENT AND APPROPRIATE REQUIREMENTS (ARARs)

- All four alternatives can comply with identified ARARs

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BALANCING CRITERIA

LONG-TERM EFFECTIVENESS AND PERMANENCE

- The treatment technologies combined with disposal in an arid environment provide approximately equal long-term effectiveness and permanence

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SHORT-TERM EFFECTIVENESS

- Work risks are higher for vitrification, and encapsulation technologies because of higher operating temperatures
- Transportation risks for all alternatives are significantly below U.S. EPA guidelines
- Transportation risks are lowest for vitrification due to smaller number of waste shipments
- Offgas issues more significant for vitrification and encapsulation technologies
- Time to protectiveness (cleanup time) is judged to be most certain for cement stabilization as the most developed tecnology

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REDUCTIONS OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Mobility:
- All technologies reduce RCRA metals mobility to below regulatory limits

Volume:
- Vitrification will realize a reduction of the treated waste
  - Must consider secondary wastes
- Cement stabilization will realize a volume increase (approximately 20%) in the treated waste
- Sulfur/Polymer Encapsulation and Polymer Encapsulation are expected to perform similar to cement stabilization relative to volume increase

Toxicity:
- None of the treatment technologies achieve a significant reduction in waste toxicity

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COST

Vitrification: $61.1M (Total Present Worth)

Cement Stabilization: $25M (Total Present Worth)

Sulfur/Polymer Encapsulation: Comparable to Cement Stabilization*

Polymer Encapsulation: Comparable to Cement Stabilization*

***Based on U.S. EPA Reference Material**

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IMPLEMENTABILITY

Administrative Implementability:

- All alternatives judged to be equally implementable from an administrative perspective (i.e., ability to meet offsite waste acceptance criteria)

Technical Implementability:

- Based on commercial availabilty and industry experience, cement stabilization implementability is judged to be most certain
- Greater uncertainty exists for encapsulation technologies due to lack of commercial development
- High waste sulfate content significantly increases uncertainty for vitrification implementability

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NTS APPROVAL PROCESS FOR TREATED SILO 3 WASTES

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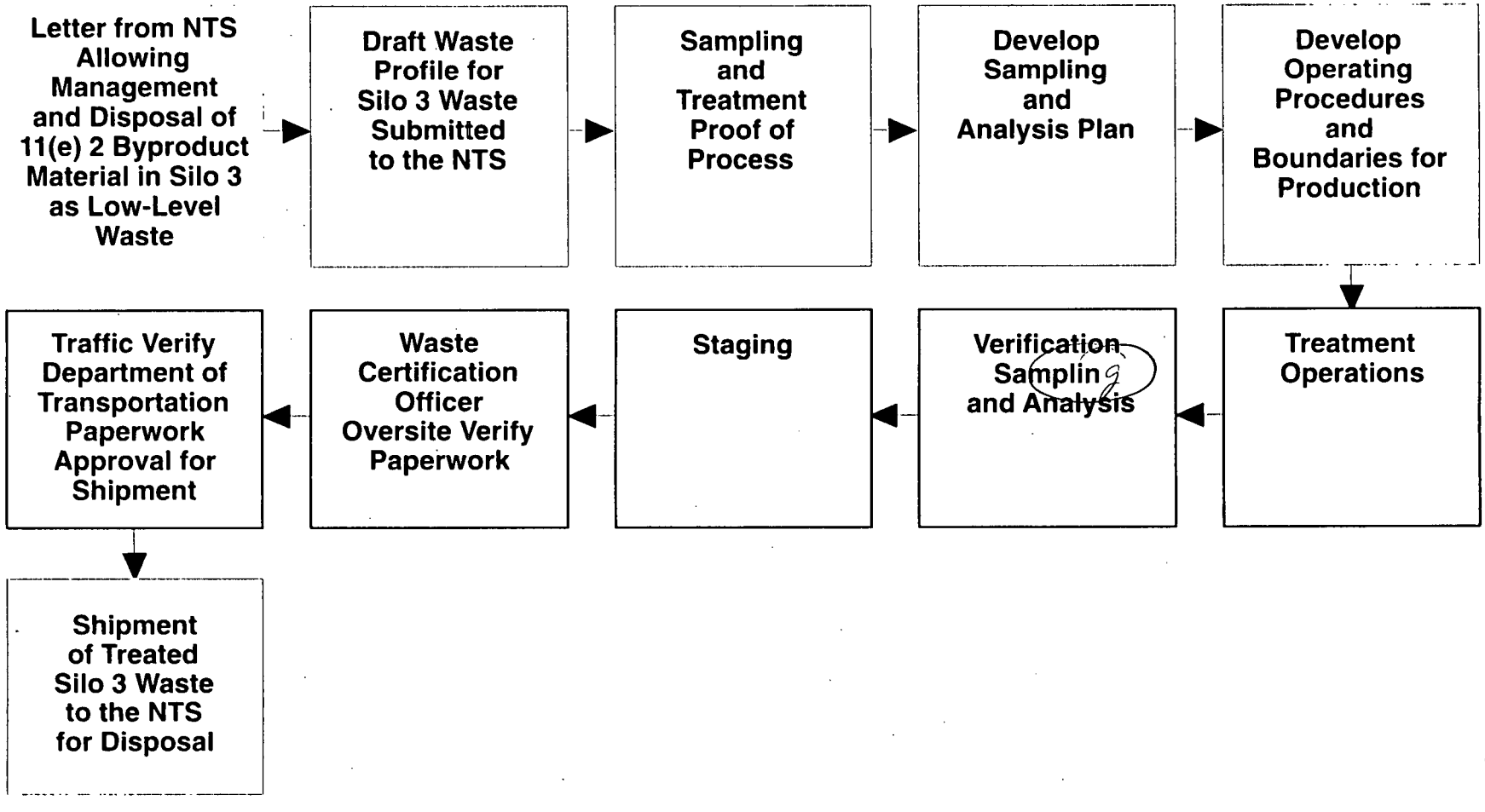

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FERNALD

Comparision of Non-Radiological Risks to Workers and the Public Resulting from Transport of Treated Silo 3 Wastes by Direct Truck to the NTS

Alternative	Public Injury	Public Fatality	Worker Injury	Worker Fatality
Vitrification	0.07	0.007	0.02	0.001
Cement Stabilization	0.1	0.01	0.05	0.002
Polymer Encapsulation *	0.1	0.01	0.05	0.002
Sulfer Polymer Encapsulation *	0.1	0.01	0.05	0.002

* Based on literature review, a waste loading of 45% for the encapsulation processes could be expected. This is the same waste loading expected for cement stabilization. Assuming the waste product generated from the treatment process has roughly the same density (approximately 100 lb/ft ^{3}) and the same total volume of treated material (approximately 6,088 yd^3) as cement stabilized waste, the number of shipments to the NTS and therefore the risk to the public and transportation workers would be similar.

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Comparision Lifetime Cancer Risk to the Maximally Exposed Member of the Public Resulting from Normal Transport of Treated Silo 3 Wastes by Direct Truck to the NTS

Alternative	Lifetime Cancer Risk - Maximally Exposed Member of the Public During Normal Transport
Vitrification	3×10^{-10}
Cement Stabilization	8×10^{-10}
Polymer Encapsulation *	8×10^{-10}
Sulfer Polymer Encapsulation *	8×10^{-10}

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REVIEW OF WASTE STABILIZATION TECHNOLOGIES

Don Paine, Silos Project Manager

SILOS PROJECT

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EPA
Remediation Technologies, Screening Matrix
Soils, Sediments, Sludges

Physical/Chemical Processes	Thermal Processes	Other Processes
1. Solidification/Stabilization Full-Scale/Conventional	1. High Temperature Thermal Desorption Full-Scale/Innovative	1. Excavation and Off-Site Disposal Full-Scale/Conventional
2. Solvent Extraction Full-Scale/Innovative	2. Vitrification Full-Scale/Innovative	
3. Chemical Reduction/Oxidation Full-Scale/Innovative		

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SILOS PROJECT

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Proposed technologies to carry forward for detailed evaluation

- Cement Stabilization/Solidification
- Polymer (Micro) Encapsulation
- Sulfur/Polymer Encapsulation
- Vitrification

WASTE TREATMENT PROCESSES

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- **Stabilization**
  - Chemically react contaminants with reagents to form insoluble compounds. BDAT: Toxic Metal Waste
- **Encapsulation**
  - Physically isolate contaminants from environment. BDAT: Debris; ALT: Toxic Metal Waste
- **Solidification**
  - Convert liquid to solid
  - Convert fine powder to non-dusting solid. BDAT: N/A
- **Vitrification**
  - Melt mixture of waste and frit to form glass waste. BDAT: HLW

CEMENT-BASED MATERIAL

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Cement + Sand + H_2O → Mortar, Grout
Cement + Sand + Gravel + H_2O → Concrete
Cement + Aqueous sludge/solution → Waste Form
Cement + Dry Waste + H_2O → Waste Form

± Mineral reactive additives(Pozzolans)
± Additives for processing
± Chemicals or materials for cured property improvements

MATERIALS USED IN WASTE STABILIZATION

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- Hydraulic Cement
  - Portland
  - Slag
  - Calcium Aluminum Sulfate
  - Gypsum
  - Limes
- Pozzolans
  - Fly Ash
  - Natural
- Zeolites
  - Natural
  - Manufactured
- Clays
  - Natural
  - Processed
- Chemically reactive ingredients for specific contaminant stabilization/treatment

CEMENT WASTE FORM DESIGN

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- Select cement, mineral additives, processing additives, and stabilization reagents to produce a material which meets production, storage, transportation and disposal requirements.

CEMENT WASTE FORMS

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- **ADVANTAGES**
  - Tailor properties
  - Ambient temperature
  - No off gas
  - Rework
  - Broad experience
  - Materials available
  - Vendors
  - One step processing liquids/sludges

- **DISADVANTAGES**
  - Cement hydration (solidification) sensitive to waste composition
  - QA issues for multiple component systems
  - Dust control required
  - Potential bleed water
  - Exothermic reaction
  - High density of cement additives
  - Container corrosion

SULFUR POLYMER MATERIAL

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- Developed in 1970s as an acid resistant construction material in an effort to find uses for sulfur generated as by-product waste in the petroleum industry

Elemental Sulfur 95% + Additives 5% —Melt 130-150°→ Molten Sulfur —Cool→ Modified sulfur polymer

- Adapted to waste encapsulation by DOE

SULFUR POLYMER

FERNALD

- **ADVANTAGES**
  - Solidification assured
  - Compatible with many wastes
  - Rapid hardening
  - Resistant to many chemicals
  - No gas generation due to radiation
  - No free liquid
  - Low leaching
  - Rework

- **DISADVANTAGES**
  - Requires drying (<1% water)
  - Pre-heat waste
  - Off gas
  - SP deforms > 90°C
  - Limited waste processing experience

POLYETHYLENE MATERIAL

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- Polyethylene developed in 1930s
- Organic Polymer - Low density used for waste encapsulation

Polyethylene Pellets + Dry Waste → (Melt 150°C, Extrusion Press < 200 psi) → Polyethylene Encapsulated Waste

POLYETHYLENE MICROENCAPSULATION

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- **ADVANTAGES**
  - Insensitive to waste chemistry
  - Broad range of molecular weights
  - No chemical reaction for solidification
  - Rework

- **DISADVANTAGES**
  - Pre-dry waste (< 2% H_2O)
  - Foaming potential
  - Vent gases
  - Processing hazards > 350°C
  - No production scale experience
  - No stabilization

CONCLUSIONS

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- All 3 waste forms can be designed to meet disposal requirements for many waste streams including Silo 3