U-006-405.1

4742

PROPOSED PLAN FOR OPERABLE UNIT 4 DRAFT AUGUST 1993

09/08/93

DOE/EIS-0195D
DOE-FN/EPA
100
PLAN
OU4

4742

PROPOSED PLAN FOR REMEDIAL ACTIONS AT OPERABLE UNIT 4 DOE/EIS-0195D

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

SEPTEMBER 1993

U.S. DEPARTMENT OF ENERGY
FERNALD FIELD OFFICE

DRAFT

4742

Documents Comprising the Draft
Feasibility Study/Proposed Plan-Environmental Impact Statement
for Remedial Actions at Operable Unit 4, the Fernald Environmental Management Project

DOE/EIS-0195D

Feasibility Study for Operable Unit 4, Fernald Environmental Management Project, Volume I-III, Department of Energy, Fernald Field Office, Fernald, Ohio, September 1993.

Proposed Plan for Remedial Actions at Operable Unit 4, Fernald Environmental Management Project, Department of Energy, Fernald Field Office, Fernald, Ohio, September 1993.

Incorporated by reference:
Remedial Investigation Report for Operable Unit 4, Fernald Environmental Management Project, Volume I-III, Department of Energy, Fernald Field Office, Fernald, Ohio, August 1993.

TABLE OF CONTENTS

1.0 Introduction 1

2.0 Description and History of the Fernald Environmental Management Project 5

2.1 Site History 5

2.2 Site Description 7

3.0 Scope and Role of Operable Units 12

3.1 The Operable Unit Concept 12

3.2 Scope and Role of Operable Unit 4 13

4.0 Summary of Contamination and Risks 17

4.1 Characteristics of the Operable Unit 4 Stored Residue Inventories 17

4.2 Overview of the Nature and Extent of Contamination 19

4.3 Volume of Waste and Contaminated Media Requiring Remedial Action 21

4.4 Overview of the Baseline Risk Assessment 22

4.5 Overview of the Baseline Ecological Risk Assessment 38

5.0 Summary of Alternatives 42

5.1 No-Action Alternative for All Subunits 44

5.2 Subunit A - Silos 1 and 2 contents 44

5.3 Subunit B - Silo 3 Contents 52

5.4 Subunit C - Silos 1, 2, 3 and 4 Structures, Soils and Debris 57

6.0 Evaluation of Alternatives 65

6.1 Evaluation Criteria 65

6.2 Summary of the Comparative Analysis of Alternatives 66

6.3 Identification of the Preferred Remedial Alternative for Operable Unit 4 88

7.0 Community Participation 99

Glossary 100

References 104

Proposed Plan/Other Document Cross Reference Matrix 107

4742

LIST OF FIGURES

2-1 Former Site Production Process 6

2-2 FEMP and Vicinity 9

2-3 FEMP Site Map 10

2-4 Waste Storage Area 11

3-1 Operable Unit 4 Area 14

6-1 Operable Unit 4 Preferred Alternative Flowchart 90

6-2 Proposed Location of Operable Unit 4 On-Property Disposal Facility 92

6-3 Operable Units 3, 4, and 5 Coordination Schedule 95

LIST OF TABLES

4-1 Materials Volume Estimates Operable Unit 4 23

4-2 Radiological Constituents of Potential Concern, Operable Unit 4 25

4-3 Chemical Constituents of Potential Concern, Operable Unit 4 26

4-4 Baseline Exposure Scenarios, Current Land Use 30

4-5 Baseline Exposure Scenarios, Future Land Use 31

4-6 Summary of Baseline Risks 34

4-7 Uncertainties Associated with Estimated Risks for Operable Unit 4 39

5-1 Summary of Operable Unit 4 Subunit Alternatives 43

5-2 Proposed Remediation Levels in Soils 60

6-1 Comparison of Remedial Alternatives 67

6-2 Operable Unit 4 Remedial Alternative Cost Summary 79

6-3 Summary of Costs Operable Unit 4 Preferred Alternative 97

002

1.0 INTRODUCTION

This Proposed Plan for Remedial Actions at Operable Unit 4 (hereinafter called Proposed Plan) addresses the management of contaminated material in the area designated as Operable Unit 4 of the Fernald Environmental Management Project (FEMP), formerly known as the Feed Materials Production Center. The FEMP site is a government-owned facility located about 17 miles (27 kilometers) northwest of Cincinnati, Ohio. From 1952 until 1989, the FEMP site provided high-purity uranium metal products to support United States defense programs. Production was stopped due to declining demand and a recognized need to commit available resources to remediation. The FEMP site is included on the National Priorities List of the U. S. Environmental Protection Agency (EPA). Inclusion on the National Priorities List reflects the relative importance placed by the federal government on ensuring the expedient completion of cleanup operations at the FEMP. The facility is owned by the U.S. Department of Energy (DOE), which as the lead agency is conducting cleanup activities at the site under its Environmental Restoration and Waste Management Program. The EPA and the Ohio Environmental Protection Agency (OEPA) are the support agencies. In addition, the three agencies actively invite local community and public involvement in decisions about the remediation of the FEMP site.

Concerns identified at the FEMP site by the DOE, EPA, OEPA, and the public include:

- The potential impacts on human health and the environment as a result of past releases of low-level radioactive and hazardous materials into the air, water and soil;
- Continuing releases of low-level radioactive and hazardous materials into the air, groundwater, and the Great Miami River;
- The accumulation of a large inventory of process materials and low-level radioactive and hazardous materials at the FEMP site.

To better manage environmental investigation and cleanup, the FEMP site was divided into five operable units. The operable units are defined by their physical locations as well as the potential for similar technologies to be used in the cleanup process.

The environmental remedial actions at the FEMP site are taken in accordance with the following environmental legislation: the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA); and by the Resource Conservation and Recovery Act of 1976 (RCRA), as amended by the Hazardous and Solid Waste Amendments of 1984 (HSWA).

In addition, it is DOE policy to integrate the National Environmental Policy Act of 1969 (NEPA) into the procedural and documentation requirements of CERCLA wherever practicable. On May 15, 1990, a Notice of Intent was published in the Federal Register indicating that DOE planned to prepare

an Environmental Impact Statement (EIS) consistent with NEPA to evaluate the environmental impacts associated with the cleanup actions for each of the five FEMP operable units. Consistent with the Notice of Intent, the resulting integrated process and documentation package are termed a Feasibility Study/Proposed Plan-Environmental Impact Statement (FS/PP-EIS).

Currently, the five FEMP operable units are at different stages for evaluating cleanup alternatives; however, each operable unit has identified a leading remedial alternative (see Appendix K of the FS Report for Operable Unit 4). As the cleanup process moves ahead, the leading remedial alternatives may be modified based on new information or on public and support agency (EPA and OEPA) comments. Functioning as the lead CERCLA/NEPA integrated document, the Operable Unit 4 FS/PP-EIS addresses cumulative environmental impacts for implementing the leading remedial alternatives for each FEMP operable unit. The NEPA cumulative analysis focuses on the potential impacts to human health and the environment as the result of implementing one or all of the leading remedial alternatives for the five FEMP operable units. The CERCLA/NEPA integrated documents prepared subsequent to Operable Unit 4 will be derived from, or be fully encompassed by, the impact analysis presented in the Operable Unit 4 FS/PP-EIS. If the leading remedial alternatives for any of the operable units change, additional NEPA review will be performed and documented as appropriate to evaluate the impacts to human health and the environment. This additional analysis will be presented in the integrated CERCLA/NEPA documents for the remaining operable units where 90 appropriate.

In accordance with both CERCLA and NEPA processes, these documents are made available to the public for comment. Public involvement is an important factor in the decision-making process for site remediation. Public comments will be considered in the remedy selection for each operable unit, which will be presented in a Record of Decision. Applying the integrated approach for CERCLA and NEPA, DOE plans to prepare and issue a single Record of Decision for each operable unit to be signed by both DOE and EPA. The contents of the documents prepared for the remedial actions at the FEMP site are not intended to represent a statement on the legal applicability of NEPA to remedial actions conducted under CERCLA.

Operable Unit 4 includes four material storage silos. Silos 1 and 2 (commonly known as the K-65 Silos) contain radium-bearing, low-level radioactive material generated from processing high-grade uranium ore. Silo 3 contains dry, low-level radioactive material residues known as "cold metal oxides," which were generated during uranium extraction operations. Silo 4 was never used and is empty, except for rainwater infiltration.

The purpose of this Proposed Plan is to facilitate public participation in the remedy selection process by:

- Identifying the initially preferred alternative for Operable Unit 4 and presenting the rationale for DOE's preference.

- Describing the other alternatives that were considered in detail within the Feasibility Study Report for Operable Unit 4.

- Soliciting public review and comment on all of the alternatives described in Section 5.0 of this Proposed Plan.

- Providing information on how the public can be involved in the remedy selection process.

This Proposed Plan highlights key information from the Operable Unit 4 Remedial Investigation and Feasibility Study reports, which are the primary sources of detailed data pertaining to the operable unit characteristics and remedial alternatives analysis. See the "Proposed Plan/Other Document Cross Reference Matrix" located on the last page of this Proposed Plan for specific cross reference information. The Remedial Investigation and Feasibility Study reports are contained in the Administrative Record file for the FEMP site, located at the Public Environmental Information Center, 10845 Hamilton-Cleves Highway in Harrison, Ohio (see Section 7.0).

In this Proposed Plan, DOE identifies an initial preference for an alternative consisting of the following components:

- Removal of contents from Silos 1, 2, and 3 the decant sump tank.

- Vitrification (glassification) of contents removed from Silos 1, 2, 3, and decant sump tank sludge.

- Demolition of Silos 1 - 4 and decontamination, to the extent practical, of the concrete rubble, piping, and other generated construction debris. Unrestricted release of materials demonstrated to attain free-release criteria.

- Removal of the earthen berms and excavation of contaminated soils within the boundary of Operable Unit 4, so as to achieve proposed remediation levels. Placement of clean backfill following excavation.

- Demolition of the vitrification treatment unit and associated facilities. Decontamination or recycling of debris prior to disposition. Unrestricted release of materials demonstrated to attain free-release criteria.

- Off-site shipment for disposal at the Nevada Test Site of the vitrified contents of Silos 1, 2, 3, and the decant sump tank.

- On-property interim storage of excavated contaminated soils and remaining debris in a manner consistent with the approved Work Plan for Removal action 17 (Improved Storage of Soil and Debris).

- Continued access controls and maintenance and monitoring of the stored waste inventories.
- Potential additional treatment of stored Operable Unit 4 inventories using Operable Units 3 and 5 waste treatment systems.
- Place in abeyance the final decision regarding the final disposition of remaining Operable Unit 4 contaminated soils and debris.
- Disposal of remaining Operable Unit 4 contaminated soils and debris consistent with selected remedies for Operable Units 3 and 5.

The identification of the preferred alternative in the Proposed Plan is only an initial recommendation. The DOE, in conjunction with EPA, will consider public comments as well as those from OEPA. Changes to the preferred alternative or a change to another alternative may result if public and agency comments or additional data indicate such a change would result in a more appropriate selection. Therefore, all interested individuals are encouraged to provide comments on the alternatives presented in this Proposed Plan (refer to Section 7.0). The final decision regarding the selected remedy will be documented in a Record of Decision after all comments from the public and OEPA are taken into consideration. A summary of DOE's responses to these comments (called a Responsiveness Summary) will be included in the Record of Decision Document and made available in the Administrative Record.

The Proposed Plan includes the following:

- Section 2.0 presents the history and description of the site.
- Section 3.0 defines the concept of the operable unit, subunits, and scope and role of Operable Unit 4.
- Section 4.0 summarizes the nature and extent of contamination in Operable Unit 4 and risks to human health and the environment if no action is taken.
- Section 5.0 summarizes the remedial alternatives being considered for Operable Unit 4.
- Section 6.0 summarizes the evaluation of remedial alternatives and summarizes DOE's initially preferred alternative.
- Section 7.0 describes the opportunities for public involvement.
- A glossary defining key terms and acronyms.
- A reference list which serves as a bibliography.
- A cross reference matrix which provides information on where expanded discussion relative to text in Proposed Plan Sections can be located.

2.0 DESCRIPTION AND HISTORY OF THE FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

2.1 SITE HISTORY

2.1.1 Overview of the FEMP Site's Production Activities

During its 37 years of operation, the FEMP site's primary mission was to process uranium into metallic "feed" materials, which were shipped, or "fed," to other DOE facilities for use in the nation's atomic weapons program. The principal products were variously sized, highly purified uranium metal forms of assorted standard isotopic assays. Uranium metal required a series of chemical and metallurgical conversions which occurred in nine specialized plants. The finished metal products were then shipped to Rocky Flats, Colorado; Savannah River, South Carolina; Oak Ridge, Tennessee; and Hanford, Washington for DOE use.

The production process at the FEMP site began with the purification of uranium contained in materials that were recycled from production and were received from other sites. Scrap metals generated on site or received from other sources were also refined for production. The materials were then heated in a furnace which upgraded them to chemical processing requirements (see Figure 2-1).

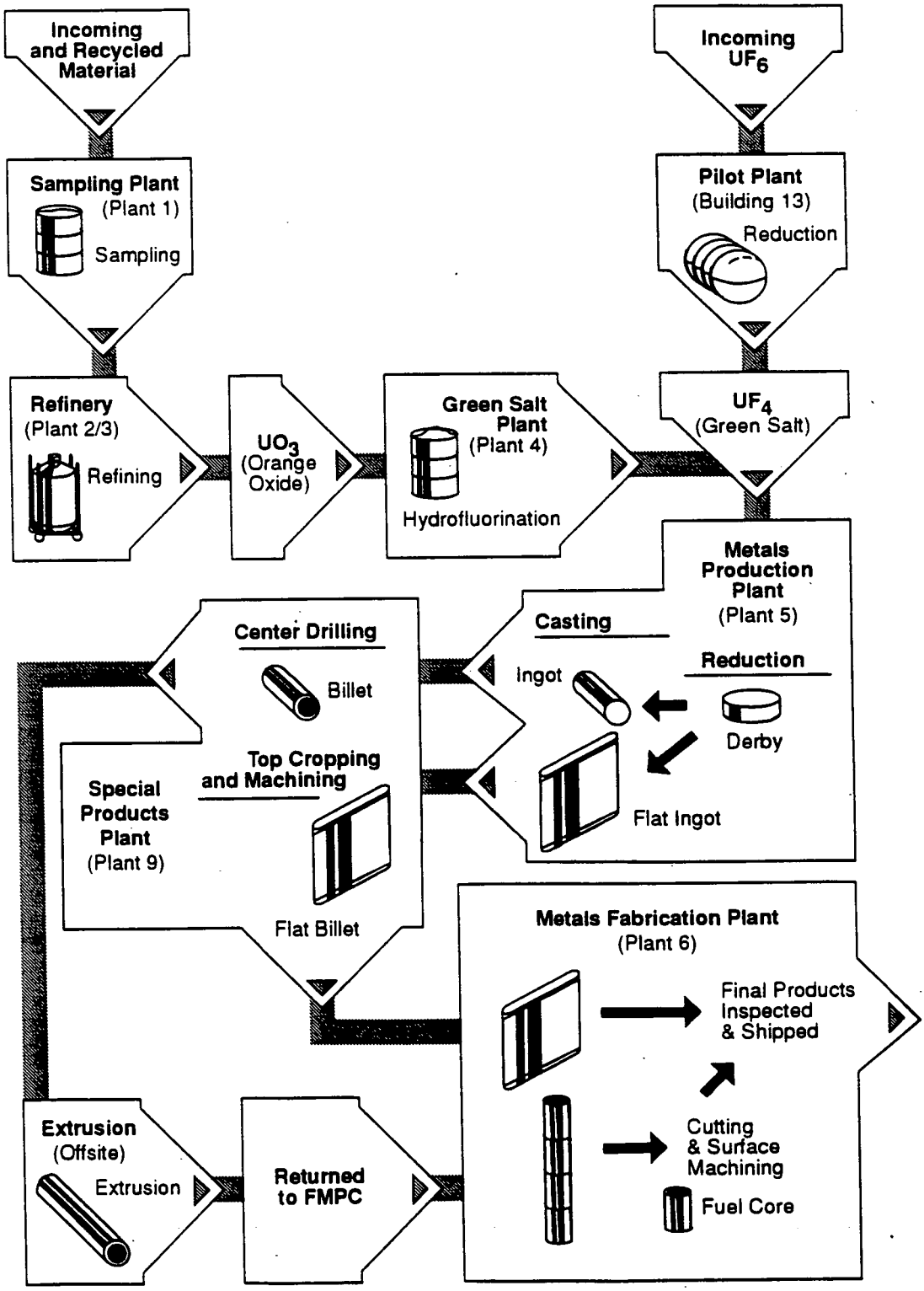
Initially, the materials from the Sampling Plant were dissolved in nitric acid to produce a crude uranyl nitrate solution (UNH) for solvent extraction purification. Purified UNH was concentrated to uranium trioxide (UO_3), or orange oxide. Orange oxide was then converted to uranium tetrafluoride (UF_4), or green salt, for reduction to metal. Green salt was also produced at the FEMP site from uranium hexafluoride (UF_6) received from other DOE sites.

To begin metal production, UF_4 was blended with magnesium granules and placed in a closed reduction pot. The reduction pot was heated in a furnace until the contents reacted to produce uranium metal shaped in forms called derbies weighing 136 to 168 kilograms (300 to 370 pounds). Some derbies were sent directly to other DOE sites; however, most were cast into ingots at the FEMP site.

Ingots were formed by melting derbies, along with metallic scrap and briquettes recycled from earlier production and fabrications, in a graphite crucible inside a vacuum induction furnace. When the molten metal reached the proper temperature, it was bottom poured into a graphite mold to form ingots.

4742

FIGURE 2-1
FORMER SITE PRODUCTION PROCESS



Ingots varied in weight, size, and shape according to how they were used. In the late 1960s, all cylindrical ingots were center drilled at the FEMP site and sent off site for extrusion (the process of forming metal in tubes). Most of these extruded tubes were returned to the FEMP site for heat treatment and finally machined before they were again shipped off site for use at other DOE sites.

4742

2.1.2 Operating History of the FEMP Site

The FEMP site was constructed in 1950 and 1951 under the authority of the Atomic Energy Commission, later known as the Energy Research and Development Administration and eventually the DOE. In 1951, National Lead of Ohio, Inc., entered into contract with the Atomic Energy Commission as the Operations and Maintenance Contractor for the facility. National Lead of Ohio, Inc., was the site's prime operating contractor until January 1, 1986.

Operations began in 1951 upon completion of the Pilot Plant, the site's first operational facility. In 1960, production reached its peak at approximately 12,000 metric tons (13,200 tons) of uranium per year. Beginning in 1964, reduced demand led to production declines which reached a low of approximately 1230 metric tons (1355 tons) in 1975. During the 1970s, reduced demand for uranium products caused capital improvements and staffing to be minimized, and the site was nearly closed. The staffing level, which peaked at 2,891 personnel in 1956, slowly declined to 662 personnel in 1972 and then to 538 personnel in 1979. In 1981, the FEMP site began planning to accommodate increased production requirements due to the government's interest in the Strategic Defense Initiative program. Production levels significantly increased, and there was a rapid staff increase for several years, combined with the implementation of a major facilities restoration program.

On January 1, 1986, Westinghouse Materials Company of Ohio, a wholly-owned subsidiary of Westinghouse Electric Corporation, assumed Operations and Management responsibility for the site.

Production was ceased in the summer of 1989 due to a declining demand for uranium feed product, and plant activities were focused on environmental cleanup. In June 1991, the site was officially closed for production by an act of Congress. To reflect its evolution to a new mission, the site was renamed the Fernald Environmental Management Project. Shortly thereafter, the DOE developed the concept of an Environmental Restoration Management Contractor to oversee the site's cleanup and remediation. On December 1, 1992, Fernald Environmental Restoration Management Corporation (FERMCO), a wholly-owned subsidiary of Fluor Daniel Inc., assumed responsibility for managing the restoration.

2.2 SITE DESCRIPTION

The FEMP site is a 425 hectare (1050 acre) facility located just north of Fernald, Ohio, a small farming community, and lies on the boundary between Hamilton and Butler Counties. Of the total site area, 345 hectares (850 acres) are in Crosby township of Hamilton County, and 80 hectares (200

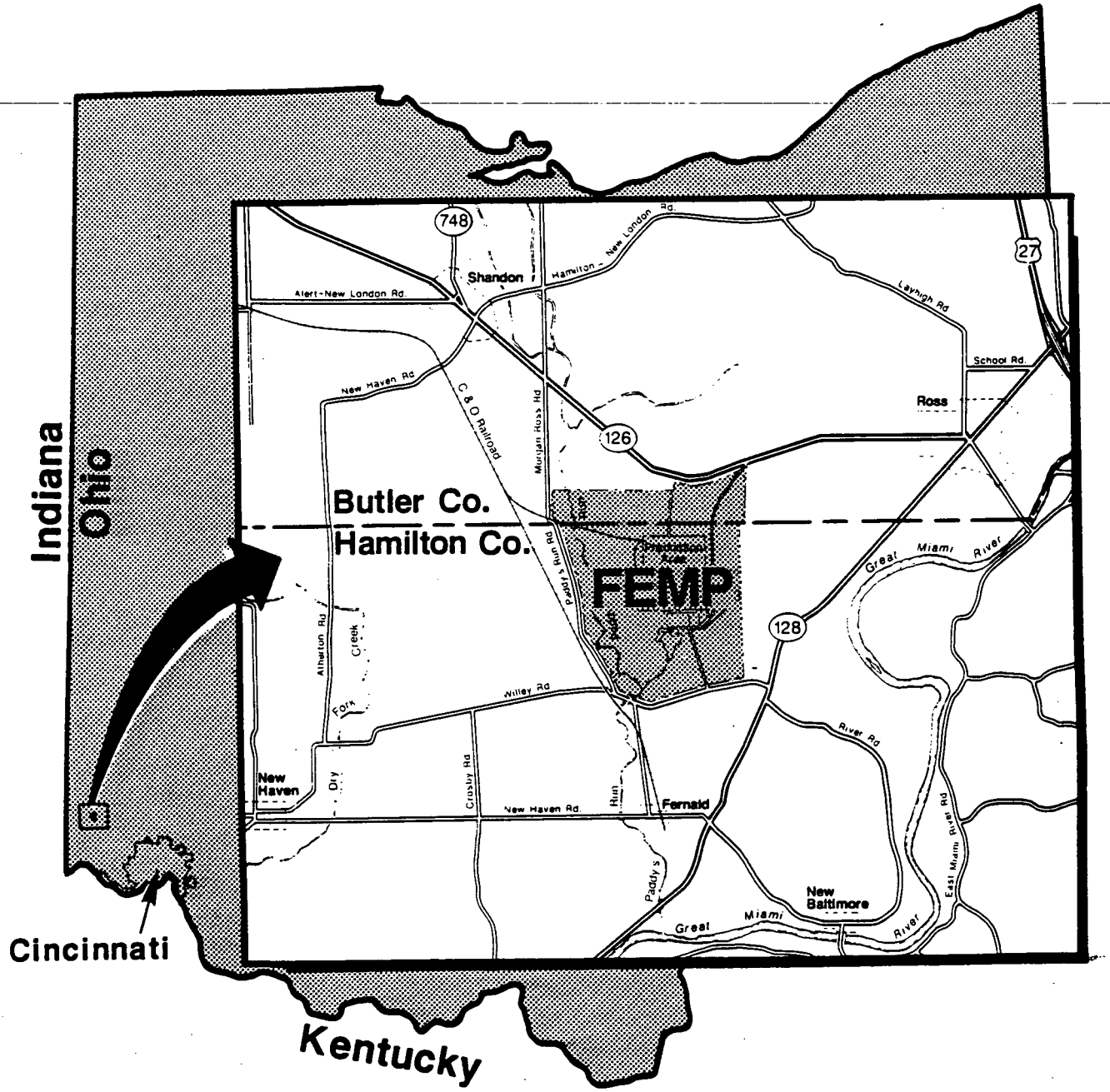
009

acres) are in Ross and Morgan Townships of Butler County. Other nearby communities include Shandon, New Baltimore, Ross, and Harrison (See Figure 2-2).

Production operations at the facility were limited to a fenced 55-hectare (136-acre) tract of land known as the former Production Area, located near the center of the site. Large quantities of liquid and solid materials were generated during production operations. Prior to 1984, solid and slurried materials from uranium processing were stored or disposed of in the on-site Waste Storage Area. This area, located west of the former Production Area (see Figure 2-3), included six low-level radioactive waste storage pits; two earthen-bermed, concrete silos containing K-65 residues; one concrete silo containing cold metal oxides; one unused concrete silo; two lime sludge ponds; a burn pit; a clearwell; and a solid waste landfill (see Figure 2-4).

Operable Unit 4 is located within this on-site Waste Storage Area. A discussion related to the nature and extent of contamination found in Operable Unit 4 is presented in Section 4.1. Since the focus of this Proposed Plan is specific to Operable Unit 4, no information on site-wide contamination is described in this document. Site-wide information is explained in the Site-Wide Characterization Report (DOE 1993b) which is available in the Administrative Record at the Public Environmental Information Center (refer to Section 7.0 for additional information).

FIGURE 2-2
FEMP AND VICINITY



The FEMP covers about 425 hectares (1,050 acres).

FIGURE 2-3
FEMP SITE MAP

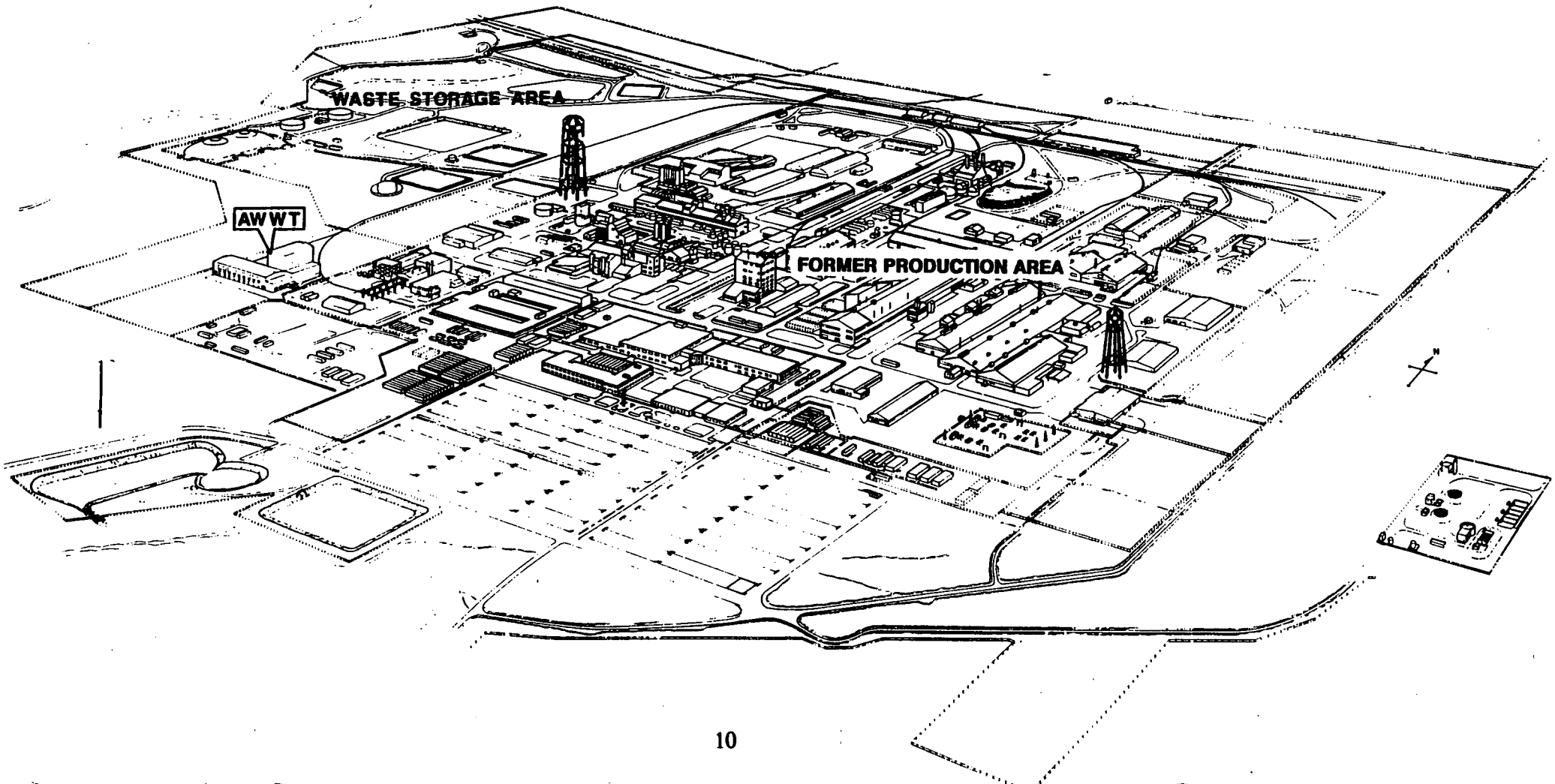
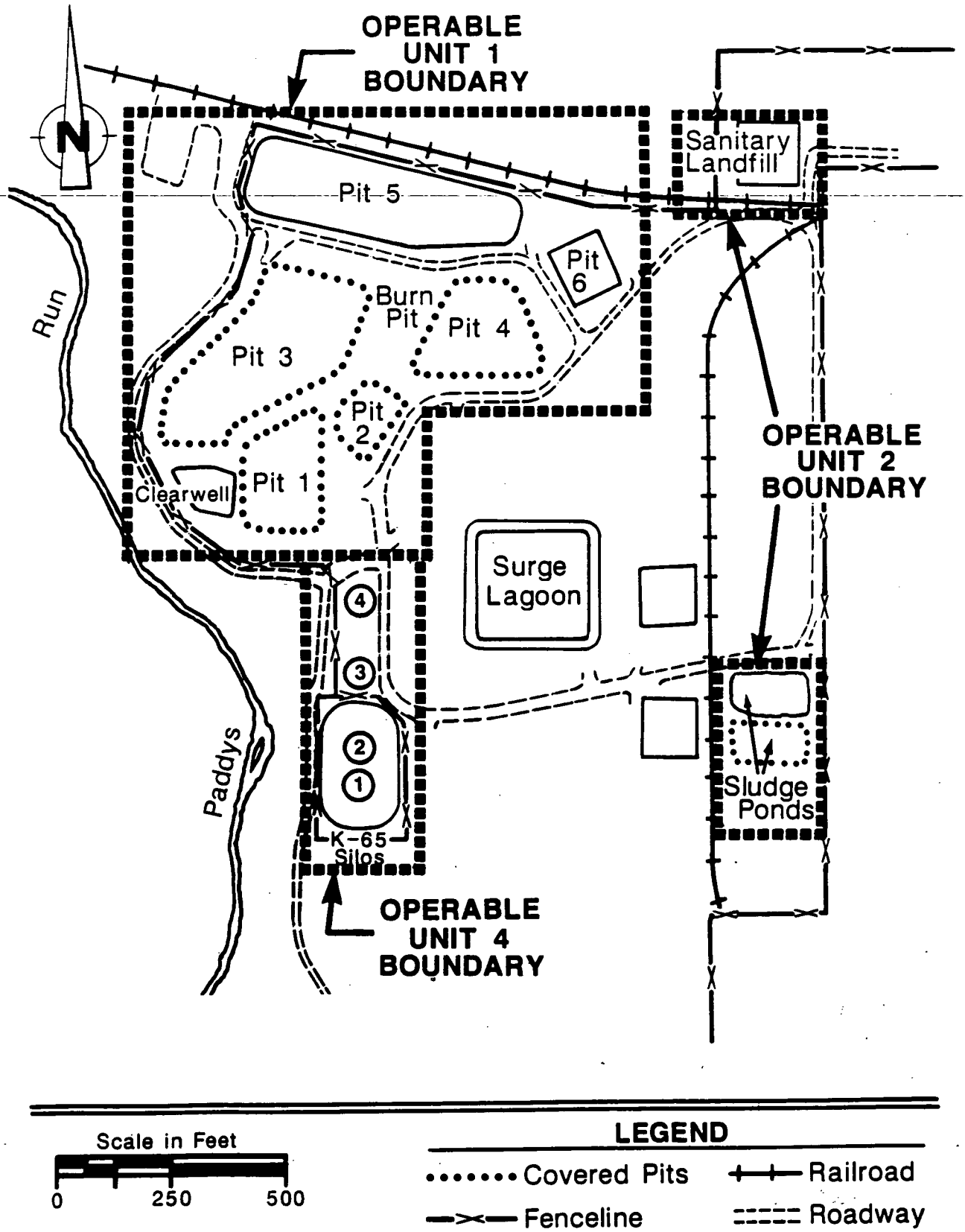


FIGURE 2-4
WASTE STORAGE AREA



3.0 SCOPE AND ROLE OF OPERABLE UNITS

3.1 THE OPERABLE UNIT CONCEPT

The EPA issued a Notice of Noncompliance to the DOE in 1985, identifying major concerns over potential environmental contamination caused by the FEMP site's production operations. In 1986, a series of conferences and negotiations between the DOE and the EPA resulted in the Federal Facilities Compliance Agreement. A major component of this agreement was the Remedial Investigation/ Feasibility Study (RI/FS). The RI/FS Work Plan (DOE 1988) identified 39 site areas for investigation.

These 39 areas were grouped into five "operable units" to make the RI/FS process more manageable. The operable unit concept at the FEMP site involves grouping waste areas or related environmental concerns in a manner so as to permit the more expedient completion of the RI/FS process. The operable unit concept became a condition of the April 1990 Consent Agreement between the EPA and the DOE.

The Record of Decision is the final step in the RI/FS process; it establishes the selected remedial alternative and provides a time frame by which remediation efforts can begin. A summary description of the five operable units and the dates on which the Draft Record of Decision for each is scheduled to be submitted to the EPA are listed below:

Operable Unit 1: Six waste pits, a burn pit, and a clearwell
Draft Record of Decision: November 6, 1994

Operable Unit 2: Two lime sludge ponds, two flyash piles, a disposal area containing construction rubble, and a solid waste landfill
Draft Record of Decision: January 5, 1995

Operable Unit 3: The former Production Area, consisting of plant buildings, scrap metals, equipment, and drummed inventories
Draft Record of Decision: April 2, 1997

Operable Unit 4: Four concrete storage silos and associated structures, and equipment
Draft Record of Decision: June 10, 1994

Operable Unit 5: Environmental media (air, water, groundwater, and soils) not associated with other operable units
Draft Record of Decision: July 3, 1995

A sixth operable unit, known as the Comprehensive Site-Wide Operable Unit, was added as a provision of the Amended Consent Agreement (signed in 1991). This is not a specific site area; rather, it was created to enable DOE, the EPA, and the public to make a final assessment from a sitewide perspective that ongoing planned remedial actions identified in the Records of Decision for

the five operable units will provide a comprehensive remedy which is protective of human health and the environment.

3.2 SCOPE AND ROLE OF OPERABLE UNIT 4

Operable Unit 4 consists of the following site facilities and associated environmental media (see Figure 3-1):

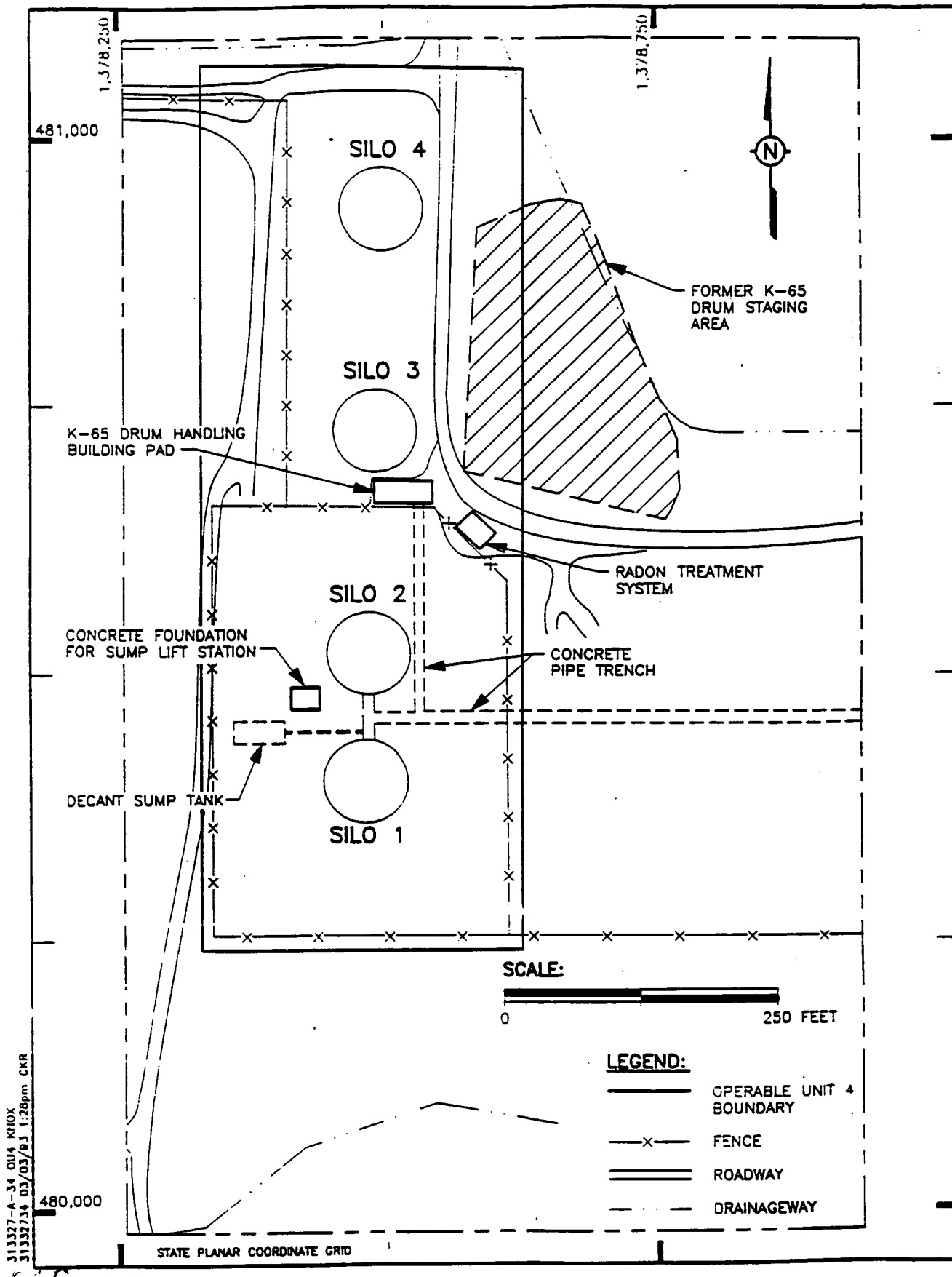
- Silos 1 and 2 (commonly known as the K-65 Silos) and their contents
- Silo 3 and its contents (cold metal oxides silo)
- Silo 4 (empty, except for rainwater infiltration)
- K-65 decant sump tank and its contents
- A radon treatment system
- A portion of a concrete pipe trench and other concrete structures
- An earthen berm surrounding Silos 1 and 2
- Soils beneath and immediately surrounding Silos 1, 2, 3, and 4
- Perched groundwater encountered in the vicinity of the silos during the implementation of cleanup activities

Originally constructed in 1951 and 1952, three of the four silos received residues until 1958. The K-65 Silos residues generated from processing uranium ores at the FEMP site, as well as residue from similar processing at the Mallinckrodt Chemical Works in St. Louis, Missouri, and from an Atomic Energy Commission storage site near Niagara Falls, New York.

The uranium ores at the FEMP site were extracted from natural uranium, termed pitchblende ores. Most of the ores were imported from the Shinkolobwe Mine in the Belgian Congo (now Zaire, in Africa). Pursuant to the terms of an agreement between the Atomic Energy Commission and the African Metals Corporation (owner of the mine), the United States owned the rights to the uranium in the pitchblende ores. The African Metals Corporation retained ownership of the precious materials in the ore, including radium and minimal amounts of gold, copper, nickel, and silver. Silos 1 and 2 were intended to provide temporary storage of the K-65 residues until they could be returned to the African Metals Corporation. After remaining in storage at FEMP for more than 30 years, ownership of the K-65 residues was transferred to the United States government in 1984.

The K-65 residues have been the focus of considerable attention from the DOE, the EPA, the OEPA, and the community due to the nature of the materials and their present storage configuration. Significant concerns associated with the Silos 1 and 2 include:

FIGURE 3-1
OPERABLE UNIT 4 AREA



- High concentrations of radionuclides, including radium and thorium, that are present in the materials;
- An elevated, direct-penetrating radiation field in the vicinity of the silos;
- Chronic emissions of radon (a radioactive gas from the decay of radium) from Silos 1 and 2 into the atmosphere;
- The structural instability of the silo domes and the age of the remaining portions of the structures;
- The potential threat of the contaminated residues leaching into the underlying sole-source aquifer.

In 1963, it became obvious that Silos 1 and 2 were deteriorating. Site workers repaired the concrete coating around each silo and constructed an earthen embankment around them to counterbalance the outward load from the silo contents. The embankment also protected the silo walls from weathering and served as a radiation shield. This embankment was expanded in 1983 to reduce erosion.

Other improvements to Silos 1 and 2 included: sealing the vents in the domes in 1979; installing plywood covers on the domes in 1986; and adding a polyurethane coating in 1987 to reduce weathering and to help lower radon emissions. This coincided with the installation of the Radon Treatment System, which was designed to draw air from the silos, remove moisture and radon through a charcoal-absorption process, and recirculate clean air back into the silos. The Radon Treatment System, which was upgraded in 1991, helped sufficiently lower radon emissions to allow workers to apply a layer of bentonite clay within the silos over the K-65 residues. The bentonite clay layer has reduced the amount of radon escaping from the silos into the environment and would help prevent the release of contaminants into the air if a natural disaster (e.g., a tornado) should occur or if the silo domes collapsed.

The contents of Silo 3 contain significant concentrations of radionuclides. The cold metal oxides in Silo 3 have a significantly lower direct radiation field and radon emanation rate than the K-65 residues in Silos 1 and 2; however, there is concern that dust particles would escape in the event of the silo structure collapsing.

Silo 4 was never used for material storage and remains empty today, except for some rainwater that has accumulated in the silo through the leaky silo dome. It is not considered a current or potential threat to the environment.

The RI/FS for Operable Unit 4 has been conducted to develop a detailed understanding of the nature of the stored materials, their impacts on the surrounding environment, and the potential threat that Operable Unit 4 components pose to human health and the environment. This detailed understanding is required to: 1) support the decision as to whether a remedial action is warranted; and 2) support

the selection of the most appropriate remedial action alternative to apply to the existing conditions within Operable Unit 4.

Operable Unit 4 represents a potential source of contamination to groundwater and other environmental media. Cleanup goals must be formulated to ultimately protect human health and the environment by isolating, removing, or treating the source of contamination.

The Remedial Investigation Report for Operable Unit 4 (DOE 1993a) supports the examination of environmental impacts by providing a description of the environment potentially affected by cleanup actions at Operable Unit 4. The Remedial Investigation Report assesses the nature and extent of contamination associated with Operable Unit 4 and also examines the impacts associated with the No-Action Alternative i.e., taking no action to remediate this operable unit's contaminants. Additionally, a Site-Wide Characterization Report (DOE 1993b), supplements the Remedial Investigation evaluation of the No-Action Alternative by providing an assessment of the cumulative environmental impacts associated with existing conditions at the FEMP site on a site-wide basis.

The Feasibility Study Report for Operable Unit 4 evaluates the range of available cleanup alternatives for the permanent disposition of the K-65 residues and cold metal oxides, the silo structures, and associated contaminated environmental media including surrounding soil and perched groundwater. The Feasibility Study Report, prepared under CERCLA, has been written to incorporate NEPA requirements. As previously stated, the Feasibility Study Report for Operable Unit 4 will be issued as a FS/PP-EIS. The Remedial Investigation Report for Operable Unit 4 was incorporated into the FS/PP-EIS by reference.

The DOE is also currently preparing a separate document called a programmatic EIS for environmental restoration and waste management at DOE facilities nationwide; the document is expected to be issued as a draft for public comment. The proposed remedial actions at the FEMP site are considered to qualify as an interim action for the programmatic EIS under the conditions established in Title 40, Code of Federal Regulations, Part 1506.1(c) [40 CFR 1506.1(c)]. The Proposed Action is justified independently of the program, would be accompanied by an adequate EIS, and does not prejudice the ultimate decision on the program by determining subsequent development or limiting alternatives. Before issuing the Record of Decision pursuant to the FS/PP-EIS for Operable Unit 4 at the FEMP site, DOE will further review the conditions of the programmatic EIS to ensure that they are met.

4.0 SUMMARY OF CONTAMINATION AND RISKS

This section provides an overview of the properties of the waste residues remaining in inventory within Operable Unit 4 and the nature and extent of contamination in environmental media associated with these stored residues. This section further provides a summary of the potential risks to human health posed by the continued storage of these materials within Operable Unit 4 and an overview of the potential risks posed by the FEMP to ecological receptors.

4.1 CHARACTERISTICS OF THE OPERABLE UNIT 4 STORED RESIDUE INVENTORIES

This section summarizes available characterization data on the nature of the radiological and chemical constituents of the residues presently stored within Silos 1, 2, and 3 in the Operable Unit 4 Study Area. Also included is a brief description of the contents of the decant sump tank located under Silos 1 and 2, the contents of Silo 4, and the radon treatment system. More detailed discussions on the nature of these stored materials and facilities can be found in Chapter 4.0 of the RI Report for Operable Unit 4.

Contents of Silos 1 and 2

Sampling conducted as part of the RI/FS on the contents of Silos 1 and 2 confirmed prior process knowledge and provided additional data regarding the distribution of constituents within the silos and their specific concentrations. These sample results also identified the presence of previously unknown organic constituents.

Silos 1 and 2 contain 6125 m^3 (8,012 yd^3) of K-65 residues and 671 m^3 (878 yd^3) of bentonite clay for a total content of 6796 m^3 (8,890 yd^3). Radionuclides at significant activity levels within these silos are actinium, radium, thorium, protactinium, and a radioactive isotope of lead (each -210). Each of these radionuclides are naturally occurring elements found in the original ores processed at the FEMP and Mallinckrodt. It is estimated that the silos contain approximately 27 metric tons (30 tons) of uranium.

Other Silos 1 and 2 residue constituents detected in significant concentrations include barium, lead, calcium, and iron. The silos also contain elevated concentrations of PCBs and tributyl phosphate (a solvent used in the former uranium extraction process at FEMP). Tests performed on samples of stored residues identified that lead could potentially be leached from the residues in concentrations which exceed federal guidelines typically applied to hazardous wastes.

Decant Sump Tank

Samples taken from the water within the decant sump tank during 1991 revealed elevated concentrations of lead-210, protactinium, radium, and uranium. Analytical results also revealed the presence of above background concentrations of strontium and technetium. With the exception of these latter two constituents, radiological contaminants present in the decant sump tank are consistent

with the relative concentrations of constituents found in Silos 1 and 2. This result confirms that the decant sump tank is continuing to collect leachate from the underdrains in Silos 1 and 2, as it was designed to do. Strontium and technetium are by-products of nuclear fission and are not present in Silos 1 and 2. Strontium and technetium were present in trace quantities in incoming process streams from other DOE facilities. They are also present in the environment due to fallout from past world-wide nuclear weapons testing. Their presence in the decant sump tank probably indicates that some surface water leached into the decant sump tank.

Metals were found in liquid samples from the decant sump tank consistent with expectations. These metals included aluminum, antimony, arsenic, chromium, copper, lead, molybdenum, selenium, silver, vanadium, and zinc.

In addition, eighteen organic compounds were detected in the decant sump tank liquids at very low concentrations. With the exception of toluene, all volatile compounds detected were at or below concentrations which represent the laboratories' ability to accurately quantify the level of the constituents.

Radon Treatment System

The existing Radon Treatment System was sampled during a removal site evaluation in January 1992. The predominant contaminant present is lead-210 and its associated decay product. Periodic surveys for direct radiation and removable fixed radioactive contamination reveal that only isolated contamination is present in accessible portions of the Radon Treatment System.

Silo 3

Silo 3 contains 3890 m^3 (5088 yd^3) of residues. During the 1989 sampling of Silo 3 contents, 12 radionuclides were identified including actinium, lead-210, and the major isotopes of radium, thorium, and uranium. The thorium isotope, thorium-230, had the highest activity concentration. These sample results are consistent with process knowledge. Also present within the silo waste is approximately 40 metric tons (44 tons) of uranium.

Of the 23 inorganic constituents detected, those which represent the highest relative hazard include arsenic and vanadium. Results from sampling in 1989 indicated that the Silo 3 residues leach arsenic, chromium, and selenium at levels exceeding comparable limits applied to hazardous wastes. It has also been concluded that organics are not present in Silo 3 residues due to high processing temperatures prior to waste transport for storage in the silos.

Silo 4

Silo 4 was never employed for the storage of wastes or in process materials and remains empty. Inspections completed on Silo 4 during the RI/FS site investigations confirmed that no waste materials

were present within the silo. Site records indicate that water has been periodically removed from Silo 4 and treated through the FEMP wastewater treatment system.

4.2 OVERVIEW OF THE NATURE AND EXTENT OF CONTAMINATION

This section summarizes the nature and extent of contamination within environmental media in the Operable Unit 4 Study Area. Environmental media within Operable Unit 4 Study Area include surface soil, subsurface soil, soils within the earthen berm surrounding Silos 1 and 2, perched groundwater, Great Miami Aquifer groundwater, surface water, sediment, and air. Also included in this section is an overview of the levels of direct radiation associated with the current conditions within Operable Unit 4. Additional detail on these conditions is provided in Section 4.0 of the RI Report for Operable Unit 4.

Surface Soil

Analytical data collected during the RI/FS detected above background concentrations of radiological and chemical contaminants in surface soil within the Operable Unit 4 area. Radionuclide concentrations detected in these samples for uranium ranged up to 30 times background levels. Concentrations of radium ranged up to 25 times background. Thorium results ranged up to 200 times natural background levels.

Of the inorganic constituents, antimony, beryllium, chromium, copper, magnesium, nickel, silver, and sodium were consistently detected above background. For organic analyses, only one sample contained elevated concentrations of semivolatiles (including benzo(a)pyrene).

In general, the results show that surface soils across Operable Unit 4 are contaminated with uranium and, to a lesser extent, radium and thorium. Concentrations decrease rapidly with depth to background levels below 15.2 cm (6 in.). The results of these samples show no direct link between surface soil contamination and the silo contents. Instead, the data show uniform distribution of low-level radiological surface contamination throughout the Operable Unit 4 Study Area consistent with air deposition of contaminants from the Waste Pit Area and/or the former Production Area.

Berm Soil

With the exception of two sampling locations, berm soil sample results revealed only background concentrations for all constituents. The first location was at a depth of 1.5 m (5 ft) in the boring near the northeast manway of Silo 1. This sample revealed above background concentrations of U-238, Th-230, Po-210 and Ra-226. The sample is considered to be more consistent with general surface soil than berm soil. The second sample was collected at a depth of 9.1 m (30 ft) from the boring located near the northwest manway of Silo 1. The sample yielded radionuclide concentrations of 600 times background levels for Ra-226 and 300 times background for Th-230. At this depth, the borehole had penetrated the native soil that was present prior to installation of the berm. Thus, this contamination could be the result of spillage during silo filling operations, leakage of the silo to

surface soils prior to berm installation, or leakage of the silo underdrains to near subsurface soils immediately adjacent to the silos.

Subsurface Soil

Radiological analyses on soil from slant borings completed underneath the Operable Unit 4 area yielded elevated concentrations of radiological contaminants. Near the interface of the berm soil with the pre-existing surface soil and near the base of the silos at their perimeter. Metals analyses performed on samples from these borings indicated elevated concentrations of heavy metal (i.e., copper, etc.) and other inorganics. The data suggest potential spillage on pre-existing surface soils and potential leakage of the silo underdrains to the subsurface soils in the immediate vicinity of Silos 1 and 2.

Analyses were performed on subsurface soil samples collected from borings within and adjacent to Operable Unit 4 and from trenches dug to the west of Silos 1 and 3. In general, subsurface soil contained concentrations of uranium at levels less than four times background. The data indicate that soil contamination in Operable Unit 4 outside of the areas immediately adjacent to and under Silos 1 and 2 is limited primarily to the surface.

Perched Groundwater

Perched groundwater is water contained within isolated zones of silt and sand within the impermeable clays existing above the underlying Great Miami Aquifer.

Samples collected form perched water in the Operable unit 4 area show that contamination has occurred directly beneath and to the west of Silos 1 and 2. Groundwater contamination, containing uranium contamination in the range of up to 1300 times background, is migrating to the west toward Paddys Run from the areas beneath Silos 1 and 2. Groundwater quality data collected from perched water indicate the presence of constituents which are consistent with those found in the decant sump tank. The presence of these constituents strongly suggest that the decant sump tank and/or associated piping are leaking.

Great Miami Aquifer Groundwater

Beneath the FEMP is a vast and prolific aquifer system called the Great Miami Aquifer. The Great Miami Aquifer is a valued and protected natural resource providing drinking water to many residents of southwestern Ohio. The Great Miami Aquifer has been designated a sole-source aquifer under the Safe Drinking Water Act establishing significant anti-degradation policies regarding the aquifer. Groundwater quality data was collected from various depths within the Great Miami Aquifer, both upgradient and downgradient of Operable Unit 4. These samples indicate uranium concentrations of up to 15 times background both up and downgradient of Operable Unit 4. The data show no direct link between contamination in the Great Miami Aquifer and the contents of Operable Unit 4 silos.

Air

The K-65 residues represent a significant potential source of radon emissions. Radon is a radioactive element which is produced through the natural decay of radium. Air quality data consisting of quarterly radon monitoring results were obtained during the period of 1989 through 1992. Monitoring results were obtained from sampling stations along the FEMP site perimeter, within the FEMP site proper, along the fence surrounding Silos 1 and 2, and along the perimeters of the Silos 1 and 2 domes. These data demonstrate the effectiveness of the K-65 Silos Removal Action conducted in November 1991, and define the area impacted due to radon gas emanating from Silos 1 and 2.

In November 1991, the FEMP site completed the K-65 Silos Removal Action. This removal action consisted of installing a layer of bentonite clay over the residues stored in Silos 1 and 2. While the action resulted in a significant reduction in direct radiation at the FEMP site fenceline, changes in radon concentrations at the FEMP property fenceline remained at background levels. In the vicinity of Operable Unit 4, however, radon concentrations immediately outside Silos 1 and 2 were reduced by as much as a factor of 20.

Direct Radiation

As a result of the presence of significant concentrations of gamma emitting radionuclides, the K-65 residues represent a significant source of direct penetrating radiation. Direct radiation levels on the surface of the Silos 1 and 2 domes prior to bentonite installation exceeded 250 times background levels. Direct radiation measurements collected along the FEMP site perimeter in 1992 after the installation of the bentonite clay in the silos show that direct radiation from Operable Unit 4 is no longer discernable above background along the site boundary.

4.3 VOLUME OF WASTE AND CONTAMINATED MEDIA REQUIRING REMEDIAL ACTION

On the basis of available site characterization data, estimates were made for the volume of wastes and contaminated environmental media requiring remedial action. These materials include:

- Waste material including K-65 residues, also known as "hot raffinates," contained in Silos 1 and 2; and metal oxides, also known as "cold metal oxide," contained in Silo 3
- Structural material and equipment including concrete and metal structural materials used in the construction of Silos 1, 2, 3, and 4 and contaminated equipment including the decant sump tank, process piping, process piping trench material, and radon treatment system equipment
- Soil within the Operable Unit 4 boundaries including surface soil around the silos, subsurface soil beneath the silos and around pipe trenches, and berm soil around Silos 1 and 2
- Residual water contained in Silo 4 and perched groundwater that may be encountered during potential remedial actions within the Operable Unit 4 boundaries

With the exception of perched groundwater encountered during potential remedial actions, surface water and groundwater are not addressed as source media within this Feasibility Study Report for Operable Unit 4. With regard to surface water, there are no surface water impoundments within Operable Unit 4. Potential remediation of groundwater contamination for the entire FEMP site is being addressed as part of Operable Unit 5. Thus, within the Operable Unit 4 Baseline Risk Assessment, groundwater is considered as an environmental receptor medium but not as a source term for which remedial actions are addressed. A volume estimate for contaminated media considered for remediation under Operable Unit 4 is presented in Table 4-1.

4.4 OVERVIEW OF THE BASELINE RISK ASSESSMENT

The chemical and radiological constituents present within the stored waste inventories and environmental media within the Operable Unit 4 Study Area present certain risks to human and environmental receptors. The type and degree of this risk has been estimated for existing or baseline conditions using EPA risk assessment methodology.

A baseline risk assessment estimates the risks that could occur in and around the FEMP site in the event no further cleanup actions are taken. These risks are evaluated for the situation as it presently exists and for how it could exist up to 1000 years in the future.

Risks to human health that might result from various hypothetical exposures to site contaminants were estimated with standard methods that have been developed by the EPA and other agencies. Two types of health effects can result from exposures to radionuclides and chemicals: carcinogenic, (e.g., lung cancer caused by inhalation of radon) and noncarcinogenic diseases (e.g., nephritis of the kidney caused by ingestion of uranium). To limit the likelihood of someone getting cancer from contamination at a CERCLA site, the EPA has established a range of from one in one million ($1x10^{-6}$) to one in ten thousand ($1x10^{-4}$) for the incremental lifetime risk of cancer associated with possible exposures (EPA 1990). Cancer risk is defined as the incremental probability of an individual's developing cancer over a lifetime as a result of exposure to a potential carcinogen (EPA 1991a). This range is referred to as the "target range" to provide a point of reference for the risk estimates presented in this section. It represents the increased probability (over the background cancer rate) that someone could get cancer during their lifetime if they were repeatedly exposed to contaminants at the FEMP site.

To put this risk range in the context of the background cancer rate, it is estimated that about one in three Americans will develop cancer during their lifetime from all causes (American Cancer Society 1992) and that the risk from exposure to radiation naturally occurring in the environment is about one in one hundred ($1x10^{-2}$), primarily from radon (EPA 1989d). Thus, the EPA target range for CERCLA cleanup sites is a very small percentage of the normal cancer risk expected in the general United States population from everyday exposures and other causes. For example, the incremental risk targeted by the upper end of EPA's range means that if all persons in a population of 10,000 were assumed to be repeatedly exposed to a site's contaminants, one person might get cancer as a result of those exposures in addition to the estimated 3,000 cancer cases expected from all other causes.

TABLE 4-1

MATERIAL VOLUME ESTIMATES
OPERABLE UNIT 4

Media	Volume		
Waste Material	Waste Residue	Bentonite Clay	Total Waste
Silo 1 contents[a]	3,282 m^3 (4,293 yd^3)	357 m^3 (467 yd^3)	3,639 m^3 (4,760 yd^3)
Silo 2 contents[a]	2,843 m^3 (3,719 yd^3)	314 m^3 (411 yd^3)	3,157 m^3 (4,130 yd^3)
Silo 3 contents[b]	3,890 m^3 (5,088 yd^3)		3,890 m^3 (5,088 yd^3)
Decant sump tank sludge[b]			3,785 L (1,000 gallons)
Structural Material and Equipment[c]			
Silo 1, 2, and 3 structures			1,530 m^3 (2,000 yd^3)
Silo 4 structure			510 m^3 (670 yd^3)
Decant sump tank, process piping, process piping trenches, radon treatment system			280 m^3 (370 yd^3)
Drum handling building pad, sump lift station concrete			20 m^3 (30 yd^3)
Soil			
Berm soil[d]			8,060 m^3 (10,540 yd^3)
Surface soil[e]			3,400 m^3 (4,440 yd^3)
Subsoil[f]			11,200 m^3 (14,650 yd^3)
Residual Water			
Decant sump tank water[g]			30,280 L (8000 gallons)
Residual water (Silo 4)[h]			49,210 L (13,000 gallons)
Water encountered during remedial actions			Unknown

[a] Volume estimate based on silo surface mapping results
[b] Volume estimate based on visual observations during sampling operations
[c] Volume estimate based on available construction drawings. Note that Silo 4 structure considered non-contaminated by process knowledge.
[d] Volume estimate based on quantity of soils comprising berms
[e] Volume estimate based on soil depth of 6 inches across entire OU4 area
[f] Volume estimate based on soil depth of 5 feet extending beneath Silos 1 and 2 to toe of berm, includes 5 foot soil depth beneath decant sump tank
[g] Assumes refilling of decant sump tank by infiltrating liquid after the most recent pumping of the decant sump tank which was completed as a maintenance action in January 1993.
[h] Volume assumed to collect based on historical in-leakage of rainwater through silo dome.

025

To address the possibility that someone could incur a disease other than cancer from contamination at a CERCLA site, the EPA has developed a measure called a hazard quotient. This quotient is determined by comparing the amount of a specific contaminant that someone might intake during exposures at a site with the dose that the scientific community considers safe or acceptable for that contaminant. Exposures to more than one contaminant can result in multiple hazard quotients. The sum of these hazard quotients equals the hazard index. If the hazard index exceeds one, a noncarcinogenic health effect might result from the estimated exposure. This value is used as the point of reference for the results presented in this discussion.

For someone to be at risk for an adverse health effect from a contaminated site, the individual must be exposed to the waste at that site. To help establish the need to undertake cleanup at a CERCLA site, the EPA evaluates the risk an individual site possesses, utilizing an assumption that no institutional controls are in place and no cleanup action is taken. By this approach, the primary hazards can be identified, and it can be determined whether someone who might enter the site could be at risk.

4.4.1 Constituents of Concern

The Remedial Investigation Report for Operable Unit 4 identified many different radiological and chemical constituents that were present within the contaminated media. However, not all of them pose significant health risks, because they are either naturally-occurring or present at levels which pose no additional risk. The Baseline Risk Assessment for Operable Unit 4 evaluated constituents and exposure pathways to ascertain their potential present and future impacts on human health. Constituents that resulted in risks to a receptor of greater than one in one million ($1x10^{-6}$) or which yielded a hazard index greater than 0.2 were designated as constituents of concern (see Tables 4-2 and 4-3).

Radiological constituents of concern, by media, are shown in Table 4-2. Chemical constituents of concern, by media, are shown in Table 4-3.

4.4.2 Exposure Scenarios for the Baseline Risk Assessment

Exposure scenarios are developed to support completion of a Baseline Risk Assessment to depict what might happen in and around the FEMP site if no further cleanup or restoration action is taken. The scenarios are used in determining the need for additional cleanup activities at the site. Five scenarios were modeled to estimate the potential risks to human and ecological receptors resulting from conditions within Operable Unit 4. In each of the five scenarios presented, the term "receptor" refers to a person whose health conditions may be affected by Operable Unit 4 contaminants. Depending on the land use, different risks to human health and the environment could occur.

The Operable Unit 4 Baseline Risk Assessment utilized two "source terms" as a way to predict future risk. The current source term assumed the silos remain in much the same condition as they are today. In the future source term, it was assumed that the Silos 1 and 2 domes collapse and the Silo 3

TABLE 4-2

RADIOLOGICAL CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 4

	Silos 1 & 2	Silo 3	Structure/ Equipment	Soil	Residual Water
Actinium-227	X	X	X		X
Lead-210	X	X	X	X	X
Polonium-210	X		X	X	X
Protactinium-231	X	X	X		X
Radium-224		X	X		X
Radium-226	X	X	X	X	X
Radium-228		X	X	X	X
Strontium-90				X	X
Technetium-99				X	X
Thorium-228	X	X	X	X	X
Thorium-230	X	X	X	X	X
Thorium-232	X	X	X	X	X
Uranium-234	X	X	X	X	X
Uranium-235/236	X	X	X		X
Uranium-238	X	X	X	X	X

TABLE 4-3

CHEMICAL CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 4

Chemical	Silos 1 & 2	Silo 3	Structure/ Equipment[a]	Soil	Residual Water[b]
Inorganics					
Antimony	X		X	X	X
Arsenic	X	X	X	X	X
Barium	X	X	X	X	X
Beryllium	X	X	X	X	X
Boron	X		X		X
Cadmium	X	X	X	X	X
Chromium	X	X	X	X	X
Cobalt	X	X	X		X
Copper	X	X	X	X	X
Cyanide	X		X	X	X
Lead	X	X	X		X
Manganese		X	X		X
Mercury	X	X	X		X
Molybdenum	X		X	X	X
Nickel	X	X	X	X	X
Selenium	X	X	X		X
Silver	X	X	X	X	X
Thallium	X	X	X	X	X
Uranium	X[c]	X[c]	X	X[c]	X
Vanadium	X	X	X	X	X
Zinc	X	X	X	X	X
Organics					
2-Butanone	X		X	X	X
2-Hexanone	X		X		X
2-Nitrophenol		X	X		X
4-Methyl-2-pentanone	X		X		X

028

TABLE 4-3
(Continued)

Chemical	Silos 1 & 2	Silo 3	Structure/ Equipment[a]	Soil	Residual Water[b]
Organics (Continued)					
4-Nitrophenol		X	X		X
Acenaphthylene				X	X
Acetone	X		X	X	X
Aldrin	X		X		X
Anthracene				X	X
Aroclor-1248	X		X		X
Aroclor-1254	X		X	X	X
Aroclor-1260	X		X		X
Benzo(a)anthracene				X	X
Benzo(a)pyrene				X	X
Benzo(b)fluoranthene				X	X
Benzo(g,h,i)perylene				X	X
Benzoic acid	X		X	X	X
Bis(2-ethylhexyl)phthalate	X		X	X	X
Carbon tetrachloride	X		X		X
Chrysene				X	X
4,4'-DDE	X		X		X
4,4'-DDT	X		X		X
Di-n-butyl phthalate	X		X	X	X
Di-n-octyl phthalate	X		X		X
Dibenzo(a,h)anthracene				X	X
Dieldrin	X		X		X
Diethyl phthalate	X		X		X
Dimethyl phthalate	X		X		X
Endosulfan I	X		X		X
Endosulfan II	X		X		X
Endrin	X		X		X

029

TABLE 4-3
(Continued)

Chemical	Silos 1 & 2	Silo 3	Structure/ Equipment[a]	Soil	Residual Water[b]
Organics (Continued)					
Fluoranthene	X		X	X	X
Heptachlor epoxide	X		X		X
Indeno(1,2,3-cd)pyrene				X	X
Methylene chloride	X		X	X	X
N-nitroso-di-n-propylamine	X		X		X
Phenanthrene				X	X
Phenol	X		X	X	X
Pyrene	X		X	X	X
Tetrachloroethene	X		X		X
Toluene	X		X	X	X
Tributyl phosphate	X		X		X
Xylenes (total)	X		X	X	X

[a] No samples collected from structures/equipment; however, it is assumed that constituents present in silos have permeated into the concrete structure.
[b] Constituents are primarily based on results of decant sump tank sampling. In addition, constituents detected in silos and soils are assumed to be present in residual water.
[c] Analysis for uranium by inductively coupled argon plasma was not performed, analysis by radiological methods.

structure collapses entirely. This would cause the Silo 3 contents to be exposed to the environment whereas the contents of Silos 1 and 2 would be somewhat contained by the surrounding berms and the bentonite cover over the K-65 residues.

It is important to consider that the DOE and the EPA have already decided that the FEMP site will undergo cleanup and remediation. The baseline exposure scenarios are used to show why cleanup is necessary and to identify the sources of contamination and the potential routes (term and pathways) by which humans or the environment could be exposed to these contaminants. Table 4-4 and Table 4-5 present the exposure pathways for each land use scenario. These scenarios are discussed in the proceeding sections.

4.4.2.1 Current Land Use With Access Restrictions (Current Source Term)

In this scenario, the FEMP site is assumed to continue to be operated by DOE as an industrial facility. The current facility access restrictions are assumed to remain in place.

Access restrictions (i.e., fencing, signs, security forces, etc.) are intended to keep people from entering contaminated site areas, such as Operable Unit 4, and thereby reduce the risk of exposure to contamination. Their presence promotes the safety of site workers and visitors.

This scenario assumes that DOE maintains a site-specific health and safety program to ensure that non-remediation workers and visitors on property are protected. Therefore, the risk assessment addresses workers subjected to short exposure durations under controlled conditions. These controls include personnel protective equipment and emission control equipment.

Under the scenario with access restrictions, members of the public are assumed to not be permitted to establish residence on the Operable Unit 4 Study Area. A trespassing child receptor is considered under this scenario in accordance with EPA's conventional practice. Also, off-property residential receptors are evaluated for this scenario. The following receptors are evaluated under this exposure scenario:

- Off-Property Farmer Receptor - Potential exposures are evaluated to a hypothetical farm family living immediately adjacent to the FEMP property boundary.
- Trespassing Child Receptor - Potential exposures to a hypothetical child who trespasses on FEMP property in the Operable Unit 4 Study Area are evaluated.
- Off-Property User of Surface Water from the Great Miami River - Potential exposures to a hypothetical user of surface water from the river are evaluated.

4.4.2.2 Current Land Use Without Access Restrictions (Current Source Term)

In this scenario, the access restrictions provided by the DOE are assumed to be discontinued, and the site continues to be used as an industrial facility, not owned by the federal government. No further

4742

TABLE 4-4

BASELINE EXPOSURE SCENARIOS
CURRENT LAND USE

CURRENT LAND USE WITHOUT ACCESS CONTROLS CURRENT LAND USE WITH ACCESS CONTROLS		
Receptor	**Exposure Pathways (Current Source Term - silos intact)**	**Exposure Pathways* (Future Source Term - silos collapsed)**
On-Property Worker/Groundskeeper	•Breathing airborne contaminants •Touching contaminants in soil •External radiation exposure from contaminated soil and silos •Incidental ingestion of soil	•Breathing airborne contaminants •Touching contaminants in soil •Touching silo contents •External radiation exposure from contaminated soil and silos •Incidental ingestion of soil and silo contents
Trespassing Child	•Breathing airborne contaminants •Touching contaminants in soil and water •External radiation exposure from contaminated soil and silos •Incidental ingestion of soil and water	•Breathing airborne contaminants •Touching contaminants in soil and water •Touching silo contents •External radiation exposure from contaminated soil and silos •Incidental ingestion of soil, water, sediment and silo contents
Off-Property Farmer (assumes the farmer lives on a property right next to the site)	•Breathing airborne contaminants •Eating/drinking farm-produced vegetables/meat/milk	•Breathing airborne contaminants •Drinking groundwater •Eating/drinking farm-produced vegetables/meat/milk •Skin contact with groundwater while bathing
Off-Property Surface Water User (assumes the person gets all home water from the Great Miami River--no groundwater)	•Ingesting surface water •Skin contact with surface water •Eating/drinking farm-produced vegetables/meat/milk or fish from the river	•Ingesting surface water •Skin contact with surface water •Eating/drinking farm-produced vegetables/meat/milk or fish from the river

*Silos are not assumed to collapse for the current land use with access controls scenario

032

TABLE 4-5

BASELINE EXPOSURE SCENARIOS
FUTURE LAND USE

FUTURE LAND USE WITHOUT ACCESS CONTROLS		
Receptor	**Exposure Pathways (Current Source Term - silos intact)**	**Exposure Pathways (Future Source Term - silos collapsed)**
On-Property Resident Farmer (assumes the farmer lives on the property and conducts agricultural activities)	•Breathing airborne contaminants •Eating/drinking farm-produced vegetables/meat/milk •External radiation exposure from contaminated soil and silos	•Breathing airborne contaminants •Drinking groundwater •Skin contact with groundwater while bathing •Eating/drinking farm-produced vegetables/meat/milk •External radiation exposure from contaminated soil and silos •Skin contact with silo waste
On-Property Resident Child	•Breathing airborne contaminants •Eating/drinking farm-produced vegetables/meat/milk •External radiation exposure from contaminated soil and silos •Touching sediments and surface water	•Breathing airborne contaminants •Drinking groundwater •Skin contact with groundwater while bathing •Eating/drinking farm-produced vegetables/meat/milk •External radiation exposure from contaminated soil and silos •Touching sediments and surface water •Skin contact with silo waste
Off-Property Farmer (assumes the farmer lives on a property right next to the site)	•Breathing airborne contaminants	•Drinking groundwater •Breathing airborne contaminants •Eating/drinking farm-produced vegetables/meat/milk •Skin contact with groundwater while bathing
Off-Property Surface Water User (assumes the person gets all home water from the Great Miami River--no groundwater)	•Drinking surface water •Skin contact with surface water •Eating/drinking farm-produced vegetables/meat/milk or fish from the river	•Drinking surface water •Skin contact with surface water •Eating/drinking farm-produced vegetables/meat/milk or fish from the river

cleanup or remediation is assumed to have been performed other than that which the DOE has already accomplished.

The risk assessment under the scenario without access restrictions also assumes that members of the public would not establish residence on the Operable Unit 4 Study Area. A trespassing child receptor and a worker receptor are considered under this scenario. These hypothetical receptors are assumed to be exposed to contaminants at locations on the existing property of the FEMP. Also, off-property residential receptors are evaluated. The hypothetical receptors evaluated under the exposure scenarios included:

- Off-Property Farmer Receptor - Potential exposures were evaluated to a hypothetical farm family assumed to be living immediately adjacent to the FEMP property boundary.

- Trespassing Child Receptor - Potential exposures are evaluated to a hypothetical child who trespasses on property in the Operable Unit 4 Study Area.

- Groundskeeper Worker Receptor - Potential exposures are evaluated to a non-DOE worker who is present on the property. The worker conducts activities in the Operable Unit 4 Study Area including groundskeeping and maintenance. No groundwater from the Operable Unit 4 Study Area would be used.

- Off-Property User of Surface Water from the Great Miami River - Potential exposures are evaluated to a hypothetical user of surface water from the river.

4.4.2.3 Current Land Use Without Access Restrictions (Future Source Term)

This scenario is identical to the previous scenario except that it assumes structural failure of the silos would occur while an industrial concern is operating on property. This structural failure scenario assumes collapse of the entire Silo 3 structure and collapse of the domes in Silos 1 and 2. Under this scenario Silo 3 metal oxide wastes are assumed to be spread over an enlarged area. K-65 residues are assumed to remain within the Silos 1 and 2 walls due to the surrounding berm fill. The principal on-property receptors evaluated under this scenario are workers and a hypothetical trespassing child, since people would not be permitted to live inside the property boundaries. Off-property farmers in the immediate vicinity and nearby residents using surface water from the Great Miami River would also be considered potential receptors. The on-property worker, the trespassing child, and the off-property farmer would be most at risk under this hypothetical exposure scenario due to exposure to chemical hazards and radiological contaminants.

4.4.2.4 Future Land Use Without Access Restrictions (Current Source Term)

The future land use scenario evaluated under the Baseline Risk Assessment assumes that existing access controls are discontinued and the FEMP property reverts to predominant land use in the area - a family farm. The hypothetical receptors considered under this exposure scenarios included:

- The Reasonable Maximum Exposure On-Property Resident Farmer Receptor - Potential exposures are evaluated to a hypothetical farmer who resides on the FEMP property and conducts agricultural activities. Typical activities may include food and feed production, livestock production, and general farm work.

- The Central Tendency On-Property Resident Farmer Receptor - Potential exposures are evaluated to a farmer who resides on the property and conducts agricultural activities. This exposure is similar to the reasonable maximum exposure resident farmer with modifications of exposure parameter values to more closely reflect values typical of actual living conditions.

- On-Property Resident Child Receptor - This receptor is similar to the reasonable maximum exposure resident farmer with modifications of exposure parameter values to reflect values typical of a child.

- Off-Property Farmer Receptor - Potential exposures are evaluated to the hypothetical farmer who lives immediately adjacent to the FEMP property boundary.

- Off-Property User of Surface Water from the Great Miami River - Potential exposures are evaluated to a hypothetical user of surface water from the river.

4.4.2.5 Future Land Use Without Access Restrictions (Future Source Term)

This scenario is identical to the previous one in that access restrictions are assumed to be discontinued, and the facility reverts to a family farming land use. It differs from the previous scenario in that it assumes that Silo 3 eventually collapses and its contents spill, contaminating the surface soil in the Operable Unit 4 Study Area. It also assumes that the Silos 1 and 2 domes also collapse, however; the K-65 residues would be contained within the silo walls due to the surrounding berm fill. Over time, the silo contents would begin leaching to groundwater through the infiltration of rainwater.

The main receptors considered under this scenario include the hypothetical on-property resident farmer (reasonable maximum exposure and central tendency), the on-property resident child, and the off-property resident.

4.4.4 Current and Potential Site Risks

Table 4-6 presents the results of the Baseline Risk Assessment for each of the identified exposure scenarios. To assist in evaluating the potential risks to each of the identified receptors, a number of mathematical models were employed to estimate the concentration of contaminants through the environment from the Operable Unit 4 area. The models assist in predicting the affects that the physical processes of nature will have on the movement of contaminants through the environment.

TABLE 4-6
SUMMARY OF BASELINE RISKS

Land Use/ Source Term	Type of Risk	Trespassing Child	Grounds Keeper	Off-Site Resident Farmer	Off-Site User of Surface Water	CT On-Property Resident Farmer	RME On-Property Resident Farmer	On-Property Resident Child
Current Land Use Without Access Controls/Silos Intact	Lifetime Cancer Risk	5.0×10^{-3}	1.0×10^{-4}	4.0×10^{-5}	3.0×10^{-7}	NA	NA	NA
	Dominant: Pathway Source Constituent	dermal contact soils beryllium	external radiation soils Ra-226	milk consumption air indeno()pyrene	fish ingestion surface water benzo(b)fluoranthene			
	Secondary: Pathway Source Constituent	external radiation soils Ra-226	dermal contact soils beryllium					
	Chemical Hazard Index	1.0	0.1	0.05	0.0004	NA	NA	NA
	Dominant: Pathway Source Constituent	dermal contact soils antimony	dermal contact soils antimony	veg/fruit deposition air uranium	veg/fruit ingestion surface water acetone			
Current Land Use Without Access Controls/Silos Collapsed	Lifetime Cancer Risk	1.0×10^{-2}	2.0×10^{-2}	1.0×10^{-4}	2.0×10^{-5}	NA	NA	NA
	Dominant: Pathway Source Constituent	external radiation soils Ra-226	external radiation soils Ra-226	veg/fruit deposition air arsenic	drinking water surface water U-238			
	Secondary: Pathway Source Constituent	external radiation soils Th-228	external radiation soils Th-228	inhalation air arsenic	fish ingestion surface water arsenic			
	Chemical Hazard Index	60.0	20.0	5.0	0.002	NA	NA	NA
	Dominant: Pathway Source Constituent	dermal contact soils uranium	inhalation air cobalt	inhalation air cobalt	drinking water surface water uranium			
	Secondary: Pathway Source Constituent	inhalation air cobalt						

TABLE 4-6

SUMMARY OF BASELINE RISKS (CONTINUED)

Land Use/ Source Term	Type of Risk	Trespassing Child	Grounds Keeper	Off-Site Resident Farmer	Off-Site User of Surface Water	CT On-Property Resident Farmer	RME On-Propert Resident Farmer	On-Property Resident Child
Current Land Use With Access Controls/Silos Intact	Lifetime Cancer Risk Dominant: Pathway Source Constituent Secondary: Pathway Source Constituent	5.0×10^{-5} dermal contact soils beryllium external radiation soils Ra-226	NA	4.0×10^{-5} milk consumption air indeno()pyrene	3.0×10^{-7} fish ingestion surface water benzo(b)fluoranthene	NA	NA	NA
	Chemical Hazard Index Dominant: Pathway Source Constituent	1.0 dermal contact soils antimony	NA	0.05 veg/fruit deposition air uranium	0.0004 veg/fruit ingestion surface water acetone	NA	NA	NA
Future Land Use/ Silos Intact	Lifetime Cancer Risk Dominant: Pathway Source Constituent Secondary: Pathway Source Constituent	NA	NA	4.0×10^{-5} milk consumption air indeno()pyrene	3.0×10^{-7} fish ingestion surface water benzo(b)fluoranthene	5.0×10^{-5} milk ingestion soil indeno()pyrene meat ingestion soil indeno()pyrene	7.0×10^{-2} milk ingestion soil indeno()pyrene meat ingestion soil indeno()pyrene	6.0×10^{-2} milk ingestion soil indeno()pyrene meat ingestion soil indeno()pyrene
	Chemical Hazard Index Dominant: Pathway Source Constituent	NA	NA	0.05 veg/fruit deposition air uranium	0.0004 veg/fruit ingestion surface water acetone	6.0 veg/fruit ingestion soils antimony	10.0 veg/fruit ingestion soils antimony	70.0 milk ingestion soils silver

037

4249

TABLE 4-6
SUMMARY OF BASELINE RISKS
(CONTINUED)

Land Use/ Source Term	Type of Risk	Trespassing Child	Grounds Keeper	Off-Site Resident Farmer	Off-Site User of Surface Water	CT On-Property Resident Farmer	RME On-Propert Resident Farmer	On-Property Resident Child
Future Land Use/ Silos Collapsed	Lifetime Cancer Risk	NA	NA	1.0×10^{-4}	2.0×10^{-6}	1.0×10^{-1}	> 1.0	2.0×10^{-1}
	Dominant:							
	Pathway			veg/fruit deposition	drinking water	external radiation	external radiation	external radiation
	Source			air	surface water	soils	soils	soils
	Constituent			arsenic	U-238	Ra-226	Ra-226	Ra-226
	Secondary:							
	Pathway			inhalation	fish ingestion	external radiation	external radiation	external radiation
	Source			air	surface water	soils	soils	soils
	Constituent			arsenic	arsenic	Th-228	Th-228	Th-228
	Pathway					veg/fruit ingestion	veg/fruit ingestion	veg/fruit ingestion
	Source					soils	soils	soils
	Constituent					Pb-210	Pb-210	arsenic
	Chemical Hazard Index	NA	NA	5.0	0.002	200	400	2000
	Dominant:							
	Pathway			inhalation	drinking water	veg/fruit ingestion	veg/fruit ingestion	veg/fruit ingestion
	Source			air	surface water	soil	soil	soil
	Constituent			cobalt	uranium	arsenic	arsenic	arsenic

Note: Shaded pathway/receptor combinations indicate an incremental increase in lifetime cancer risk of greater than 1 in 1 million, or a chemical hazard index greater than 1.

4242

Following application of these models, assumptions were made, based upon EPA guidance, as to the quantity of contaminants which a hypothetical receptor could be exposed to through ingestion, inhalation, direct contact, and direct radiation. Conservative assumptions are employed in the models and for the parameters which estimate exposure to provide an upper bound estimate of the risk each of the receptors could reasonably be expected to receive up to 1000 years into the future. For example, for the trespassing child under the current land use with access controls and current source term scenario, the child is assumed to play in Paddys Run immediately adjacent to the silos for four hours per day, for 52 days per year, for 12 years of his/her life. This hypothetical trespassing child is assumed to ingest 0.1 gram of sediment per day from a location which represents the highest measured concentration of contaminants. Similar conservative assumptions are used for potential exposure to this receptor through incidental ingestion of surface water, external radiation, and other pathways. As identified in table 4-6, the calculated incremental lifetime cancer risk to the hypothetical trespassing child is 5.0×10^{-3} (probability of 5 in 1000) under the current land use with access controls/current source term scenario. This risk is greater than the generally accepted allowable incremental lifetime cancer risk range in CERCLA of between 10^{-4} and 10^{-6}.

Similar conservative assumptions were employed to calculate the potential reasonable maximum exposures the hypothetical off-property farmer could receive as a result of the existing conditions in Operable Unit 4. For the current land use with access controls/current source term scenario, the off-property farmer is assumed to be present at a hypothetical point which exhibits both the maximum modeled air and groundwater concentrations of contaminants for 350 days per year. At this point the farmer is assumed to ingest 2 liters of groundwater per day, ingest all foodstuffs which were contaminated by air deposition of contaminants, and inhale air containing these maximum levels of contaminants. Other pathways of exposure to this receptor were also considered. On the basis of these and other assumptions, the maximum calculated incremental lifetime cancer risk to the off-property farmer is approximately 4×10^{-5} (probability of 4 in 10,000). This level is within the generally accepted allowable risk range.

The highest Chemical Index (refer to glossary) under this same exposure scenario would be 1.0 to the trespassing child, due primarily to antimony, chromium, and uranium in soil.

Of the remaining scenarios, the future land use/future source-term scenario represents the most conservative scenario considered under the Baseline Risk Assessment. Within this scenario, a family is assumed to have established a residence within the Operable Unit 4 boundaries. Additionally, the domes of Silos 1 and 2 are assumed to have failed, and Silo 3 is assumed to have suffered total structural failure, spreading its contents to the surface soil of Operable Unit 4. The dominant radiological cancer risk under this scenario approaches unity (1). The highest risk would be to the on-property resident farmer due to external radiation exposure to concentrations of radium and thorium in soils. The dominant chemical cancer risk (1.0×10^{-1}) would also be to the on-property resident farmer due primarily to ingestion of arsenic and indeno (1,2,3-cd) pyrene through the meat

and milk ingestion exposure routes. The total risk to the on-property resident farmer exceeds unity due primarily to the previously described radiological risk. The highest chemical hazard index equals 2000 under this scenario . This would be applicable to the on-property resident child due primarily to ingestion of soil and foodstuffs along with dermal contact with soil materials containing arsenic. These heightened risk levels clearly illustrate and emphasize the need for cleanup and remediation of Operable Unit 4.

4.4.5 Uncertainties

Uncertainties are associated with the information and data used in each phase of the Baseline Risk Assessment for Operable Unit 4. These uncertainties are due to a number of factors, including the conservative bias of parameters, parameter variability (random errors or natural variations), and the necessity of using computer models to predict complex environmental interactions. Uncertainties also arise from the use of animal data to predict the toxic effects and the toxic potency in humans. As EPA has pointed out in their guidance for human health risk assessments, "It is more important to identify the key site-related variables and assumptions that contribute most to the uncertainty than to precisely quantify the degree of uncertainty in the risk assessment" (EPA 1991a). Table 4-7 presents uncertainties in the Operable Unit 4 risk assessment. The potential impact on estimated risks in Table 4-7 gives a quantitative indicator of the extent to which the source of uncertainty may impact the estimates of risk presented in the scenarios. The direction of bias in Table 4-7 provides an indicator of the degree to which the source of uncertainty results in an overstatement of risk (increased conservation from a health protectiveness standpoint) or an understatement of risk (decreased conservation from a health protectiveness standpoint).

4.5 OVERVIEW OF THE BASELINE ECOLOGICAL RISK ASSESSMENT

A Site-Wide Baseline Ecological Risk Assessment was completed and included in the Site-Wide Characterization Report (DOE 1993b). The purpose of this risk assessment was to estimate the potential and future risks of FEMP site contaminants to ecological receptors (e.g., plants and animals) if no remediation is implemented. The Amended Consent Agreement between EPA and DOE stipulates that Operable Unit 5 is responsible for "Environmental Media" at the FEMP site, and therefore is designated to prepare a Site-Wide Ecological Risk Assessment as part of the Remedial Investigation Report for Operable Unit 5. Supplementary discussion on ecological risk assessment issues specific to Operable Unit 4 can be found in Section 6.3.4 of this Proposed Plan. The following discussion provides a summary of the Baseline Ecological Risk Assessment found in the Site-Wide Characterization Report.

The receptors evaluated in the Baseline Ecological Risk Assessment include all organisms, exclusive of humans and domestic animals, potentially exposed to FEMP site contaminants. The ecological risk assessment focuses on a group of indicator species selected to represent a variety of exposure pathways and trophic positions (i.e., location in the food chain). The species evaluated were the white-tailed deer, white-footed mouse, raccoon, red fox, muskrat, American robin, and red-tailed

TABLE 4-7

UNCERTAINTIES ASSOCIATED WITH ESTIMATED RISKS FOR OPERABLE UNIT 4

SOURCE OF UNCERTAINTY	POTENTIAL IMPACT ON ESTIMATED RISKS	DIRECTION OF BIAS
The applicability of the future resident farmer scenario	high	increases conservatism
Bias in silo waste sampling	high for radionuclides	increases conservatism
Assumptions in geochemical, groundwater, and air transport modeling	moderate to high	increases conservatism
Impact of sand lens beneath Operable Unit 4 on groundwater model	moderate to high	increases conservatism
Estimated volume of air released from silo headspaces	moderate to high	increases conservatism
Environmental transfer factors for contaminants	moderate to high	increases conservatism
Contaminant toxicity information	moderate to high	increases conservatism
The applicability of the trespassing child scenario under current land use	moderate	increases conservatism
Determination of the Operable Unit 4 RME from all media and exposure routes simultaneously	moderate	increases conservatism
Silo headspace radon concentration measurement data	low	neutral
High sample quantitation limits for some radiological analytical results in silo waste samples	low	decreases conservatism
Heterogeneity of waste form	moderate	increases conservatism
Assumption that concentration is uniformly distributed in contaminated medium	moderate	increases conservatism
Assumption that receptor is continuously at the point of highest air concentration	moderate to high	increases conservatism

hawk. The species were selected based on species abundance on the FEMP site, trophic position, and habitat requirements.

The assessment examined risks to terrestrial (i.e., land-dwelling) organisms associated with contaminants in two environmental media: surface soils and surface water in Paddys Run. Risks to aquatic (i.e., water-dwelling) organisms were evaluated for exposure to contaminants in Paddys Run, the Great Miami River, and in runoff into the storm sewer outfall ditch.

All nonradioactive and radioactive constituents of greatest human health risk were considered to be of concern for the ecological risk assessment. Estimated ecological risks associated with exposure to site constituents of concern are primarily due to nonradioactive inorganic chemicals in soils rather than to organic chemicals or radionuclides. This is true for both terrestrial and aquatic organisms and for plants as well as wildlife. The relative hazards to individual species varied, but the white-footed mouse consistently had the highest indices of these chemicals. This can be attributed to the assumed intake of insects by the mouse.

Estimated hazards from exposure of terrestrial organisms to constituents of concern in site surface waters were relatively low. Estimated doses to terrestrial organisms at the FEMP site, originating from soil uptake by plants and earthworms, were below levels expected to cause detectable effects. However, as with inorganic chemicals, this conclusion is sensitive to assumptions about muscle to muscle (i.e., prey to predator) transfer of radionuclides. Radiation doses due to water intake were insignificant.

Exposure to radiological contaminants at the measured concentrations in the surface waters and sediments impacted by the FEMP site does not appear to pose a risk to aquatic organisms. However, radionuclides in runoff from the site into surface water would predict estimated exposures to exceed the suggested upper limit of one rad per day (NCRP, 1991). Under this calculation, the most affected organisms would be aquatic plants, receiving a total dose from internal and external exposure of about 140 rad per day. The total dose to fish would be minimally over the limit, at 1.6 rad per day, and the total dose to benthic macroinvertebrates (e.g., crayfish) would be about 14 rad per day. Although the maximum concentrations at low flow were used in source runoff calculations, the minimum values in the storm sewer outfall ditch and Paddys Run are within the same magnitude of values. Doses to aquatic organisms in the Great Miami River would be well below one rad per day. The actual measured concentrations of cadmium, copper, mercury, and silver in surface water exceeded chronic toxicity criteria for the protection of fresh-water organisms.

Actual field studies on the impact of the FEMP site on terrestrial and aquatic communities do not indicate any effects of contaminant impacts in RI/FS plant samples from arsenic and mercury exceeding background levels (i.e., levels of a chemical or radionuclide found in uncontaminated areas near the FEMP site). In addition, although potential impacts at the individual level were predicted for

wildlife species, detrimental or adverse impacts have not been observed in the field. This indicates that the predicted potential effects have not occurred. A comparison of the concentrations of inorganic chemical concentrations in site soils to regional background values indicate the average site concentrations are similar to background values. This indication suggests that ecological risks estimated using background values of inorganics would be comparable to those estimated for the FEMP site, and emphasizes the conservative nature of the modeling method used.

In summary, although radionuclides are the most pervasive contaminants at the FEMP site, estimated ecological risks to both terrestrial and aquatic organisms are primarily associated with nonradioactive inorganic chemicals (e.g., mercury, zinc, and calcium). Although estimated potential risks utilizing computer models are substantial in some instances, they are based on soil inorganic chemical concentrations comparable to background levels, and damaging effects have not been observed in the field. This suggests that current site-specific ecological risks are low and are essentially the same as for background concentrations of these constituents. In addition, the remediation proposed by DOE will substantially reduce any future potential risks. These risks will be quantified in the Operable Unit 5 Remedial Investigation and Feasibility Study.

5.0 SUMMARY OF ALTERNATIVES

Remedial alternatives were developed by examining available technologies for cleanup that were potentially applicable to the waste materials within Operable Unit 4. These alternatives were screened to eliminate those that were impractical to implement or ineffective at addressing the hazards associated with the specific waste materials. The alternatives passing through this screening process were subjected to a detailed analysis to examine the merits of each at addressing the concerns associated with the operable unit. The results of this detailed review are compared for each of the alternatives in Section 6.0. This section provides a description of each of the remedial action alternatives passing through this screening process into the detailed analysis phase.

For more in-depth information on remedial alternatives, refer to the Feasibility Study Report for Operable Unit 4, available for review in the Administrative Record at the Public Environmental Information Center (refer to Section 7.0 of this Proposed Plan).

As previously discussed in Section 4.0, the waste materials within Operable Unit 4 exhibit a wide range of properties. Most notable would be the elevated direct radiation associated with the moist to wet K-65 residues versus the much lower direct radiation associated with cold metal oxides in Silo 3. Even more significant would be the much lower levels of contamination associated with the soils and building materials, like concrete, within the Operable Unit 4 Study Area. To account for these differences and for the varied cleanup alternatives applying to each type of waste, Operable Unit 4 was segmented into three subunits. These subunits, which are listed below, are used through the detailed evaluation of alternatives and the identification of the preferred alternative in Section 6.0.

Subunit A:	Silos 1 and 2 (K-65 residues and bentonite clay) and the sludge in the decant sump tank
Subunit B:	Silo 3 (cold metal oxides)
Subunit C:	Silos 1, 2, 3, and 4 structures; contaminated soils with the Operable Unit 4 boundary including surface and subsurface soils and the earthen berm around Silos 1 and 2; the decant sump tank; the radon treatment system; the concrete pipe trench and the miscellaneous concrete structures with Operable Unit 4, and any debris (i.e., concrete, piping, etc.,) generated through implementing cleanup for Subunits A and B.

Table 5-1 presents a brief description of remedial alternatives which were selected for detailed evaluation for each Operable Unit 4 subunit. Sections 5.1 through 5.4 provide a description of each of the Operable Unit 4 remedial alternatives which underwent a detailed analysis. Included within each alternative description is an estimate of the time to implement, the quantities of wastes handled, and the estimated total costs of the alternative. The No- Action Alternative (Section 5.1) is presented as a baseline for comparison purposes. Incorporated within each alternative involving remedial actions is the initiation of on-site cleanup activities within 15 months after the Record of Decision for

TABLE 5-1

SUMMARY OF OPERABLE UNIT 4 SUBUNIT ALTERNATIVES

OPERABLE UNIT 4 SUBUNIT	ALTERNATIVE	DESCRIPTION
Subunit A Silos 1 and 2 contents and decant tank sludge	0A 2A/VIT 2A/CEM 3A.1/VIT 3A.1/CEM	No action Removal, vitrification, on-property disposal Removal, cement stabilization, on-property disposal Removal, vitrification, off-site disposal at NTS Removal, cement stabilization, off-site disposal at NTS
Subunit B Silo 3 contents (cold metal oxides)	0B 2B/VIT 2B/CEM 3A.1/VIT 3A.1/CEM	No action Removal, vitrification, on-property disposal Removal, cement stabilization, on-property disposal Removal, vitrification, off-site disposal at NTS Removal, cement stabilization, off-site disposal at NTS
Subunit C Silos 1, 2, 3, and 4 structures, soils, debris	0C 2C 3C.1 3C.2	No action Demolition, removal, on-property disposal Demolition, removal, off-site disposal at NTS Demolition, removal, off-site disposal at Permitted Commercial Facility

Operable Unit 4 is approved by the EPA.

The cost estimates include the costs associated with designing the remedy, purchasing equipment, constructing facilities, and cleaning and demolishing these same facilities when cleanup is completed. These types of costs are termed capital costs. Also included in the costs estimates are operation and maintenance costs such as operating or maintaining any treatment equipment and providing any monitoring during or following remedial activities. In order to ensure the ability to compare cost estimates between various alternatives which could require varied time periods to complete, all costs are reported in terms of present worth. Present worth allows the estimator to account for the effects of inflation and the varied schedules for completing the remedial actions for each alternative. Each of the cost estimates assumes an annual inflation rate of seven percent and are accurate within a range of +50 to -30 percent. The total present worth cost estimate for each alternative represents the amount of money that, if invested in the first year of cleanup and paid out as required, would be sufficient to cover all capital, operating, and maintenance costs over the duration of the remedial action. Additional detailed cost estimates are presented in Appendix E of the Feasibility Study-Environmental Impact Statement (FS-EIS) Operable Unit 4.

5.1 NO-ACTION ALTERNATIVE FOR ALL SUBUNITS

The No-Action Alternative for Subunits A, B, and C is presented to provide a baseline for comparison with the other alternatives per the President's Council on Environmental Quality and the National Oil and Hazardous Substances Contingency Plan regulations. Under the No-Action Alternatives, designated as 0A, 0B, and 0C for each of the three subunits, the contaminated and/or uncontaminated materials within each subunit would remain unchanged without any further waste removal, treatment, or containment activities.

Alternatives 0A, 0B, and 0C do not provide for the monitoring of soil, groundwater, or radon emissions from the Operable Unit 4 facilities or soils, and do not provide for access controls (e.g., physical barriers and deed restrictions) taken to reduce the potential for exposure to any human or ecological receptors. The No-Action Alternative would not decrease the toxicity, mobility, or volume of contaminants or reduce public health or environmental risks. Also, goals for protecting the underlying groundwater aquifer would not be met. No costs are associated with the No-Action Alternative.

5.2 SUBUNIT A - CONTENTS OF SILOS 1 AND 2 (K-65 RESIDUES)

5.2.1 Alternative 2A/Vit - Removal, Vitrification, and On-Property Disposal

This alternative involves removal of Silos 1 and 2 contents and decant sump tank sludge using a hydraulic mining device introduced through the existing manways. This equipment would be supported by a work platform spanning the work area. The material would then be pumped through a double-walled piping system to a vitrification processing facility to be built on property. The vitrified

material would then be disposed of in an on-property above-grade disposal vault (a specially designed and constructed structure that would significantly reduce the potential for the escape of any contaminants). Because the treated material would remain on property under Alternative 2A/Vit, a review would be performed every five years by EPA, in accordance with CERCLA, to ensure the continued protection of human health and the environment.

Under Alternative 2A/Vit, approximately 6,796 m^3 (8,890 yd^3) of untreated wastes would be removed from the silos. Following treatment, approximately 2770 m^3 (3645 yd^3) of vitrified material would be placed in the on-property above-grade disposal vault. This vault would cover approximately 1.2 hectares (3 acres). With the installation of fencing and a buffer zone around the vault, up to 2.8 hectares (7 acres) would be required. The disposal of contaminated materials from the berms, Silos 1 and 2 structures, and the hydraulic mining and vitrification systems would be managed under Subunit C alternatives (Section 5.4).

The major components of this alternative include:

- Hydraulic Material Removal
- Vitrification
- On-Property Disposal in an Above-Grade Disposal Vault
- Run-On/Runoff Control of Storm water
- Monitoring and Access Restrictions During Remedial Actions
- Continued Monitoring and Federal Ownership of the Disposal Areas at the FEMP Following Remedial Actions
- CERCLA Five-Year Reviews

A material processing facility would be constructed on an estimated 3.2 hectare- (8 acre-) portion of the FEMP site. The site preparation activities would include the installation of roadways, site fencing, site lighting, process water piping, sewer lines, power poles, and the extension of site power to the processing facility. In addition, a work platform with an underlying foundation (used during removal of the material) and an above-grade disposal vault would be constructed.

The material removal work platform would be a reusable, rail-mounted, 54-meter (m) (180-ft) long structural truss bridge spanning the silos. The placement of the rail system would require the removal of part of the berms. The work platform would support the hydraulic mining device and allow the

placement of the mining device into each of the four perimeter manways as well as the center manway in each silo. The work platform would be built between Silos 3 and 4 rather than directly over either Silos 1 or 2 to minimize the risk of a construction accident impacting a silo dome.

The processing facility would be a pre-engineered metal building structure built approximately 75 m (250 ft) east of the silos and measuring 36 m by 36 m by 9 m (120 ft by 120 ft by 30 ft). The processing facility would house all material treatment and vitrified product sampling activities and equipment. The administrative areas provided within the building and the outside would be shielded from the material processing areas. A separate ventilation system with appropriate emission control equipment would be utilized to minimize the potential for the release of any contaminants during treatment.

A slurry pump with a jetting ring would be used to dislodge and transport the materials, in slurry form, to the processing facility. The slurry pump would be introduced through the silo and tank manways and would be remotely operated from a shielded control station adjacent to the work platform. This pump would consist of a flotation device with a dredging or sludge pump mounted on a swinging arm. The jetting ring and cutterheads are options that may or may not be required, depending on the nature and consistency of the waste. If the solid content of the waste is too thick or too high to pump, the jetting ring would blast the waste with high pressure water. This would loosen the material and increase the water content. The cutterhead chops up the waste and mixes it with the water to form a pumpable slurry.

A vitrification system would be used for the processing of contaminated material. Vitrification converts contaminated solids into a glass form. This glass form of waste would be extremely resilient against the effects of time and weather. The operating temperature being considered for the vitrification design [1350°C (2460°F)] would destroy organic contaminants and significantly reduce both the tendency of the waste to leach contaminants into groundwater and the emission rate of radon gas. The direct radiation associated with the treated residues would remain relatively unchanged from the untreated form of the K-65 residues.

Vitrification is considered an innovative technology. This process option is considered effective for immobilizing metals such as uranium and radium in a glass form. Studies, completed on a small scale as part of the Remedial Investigation/Feasibility Study (RI/FS), project that the volume of material requiring disposal can be reduced by over 50 percent as a result of applying the vitrification process. Vitrification is a relatively new technology without readily available equipment. The necessary equipment would be modified from available equipment used in the glassmaking industry. An electrical substation would also be built in the vicinity to supply the power required for vitrification.

After the slurried wastes enter the processing facility, they would be dewatered using a filter press (or similar equipment) to reduce the moisture content to the range necessary for vitrification. The dewatered residues would then be mixed with glass forming agents (i.e., carbon and sodium carbonate) and placed into an electrically heated melter. The molten glass would be poured directly into containers. Due to the temperatures of operation of the melter, significant quantities of steam and volatized matter would be produced. These gases would be routed through a treatment system designed to remove both solid particles and gaseous emissions, such as radon.

The silos and decant sump tank would have a recirculating radon treatment system (RTS). The RTS, consisting of dehumidification media, carbon absorbers, high efficiency particulate air filters, and a blower, would be used to treat the radon and other airborne contaminants in the headspace within the silo domes to reduce emissions during residue removal operations. The RTS would be operational during material removal and before personnel enter the area above the silo domes to reposition the slurry pump and conduct repairs or maintenance. The system and procedures would be designed to minimize exposure to personnel located over the work areas and to prevent the escape of radon and radioactive particulates from the silos and the decant sump tank. The RTS would be housed in a building adjacent to the Silos 1 and 2. All process tanks containing the slurried K-65 residues would be vented to a second RTS separate from that used for the silos and decant sump tank. This second RTS, in conjunction with the process piping/vessels design and operational procedures, would minimize potential radon and particulate emissions to the atmosphere.

All facilities and equipment installed and used by this alternative would be disassembled and decontaminated. Contaminated materials would be disposed of in accordance with the selected remedy for Subunit C.

The containerized vitrified product would be disposed of in an above-grade disposal vault located on property. The reinforced concrete vault would have a service opening to allow access for the placement of disposal boxes. The vault would be constructed on a reinforced concrete mat with a minimum thickness of 0.3 m (1 ft). The perimeter of the mat would be bounded by a curb with embedded pipes that are connected to the manholes of the underlying multimedia leachate collection/detection system to facilitate the collection of any contaminated leachate after final closure. The system would be composed of alternating composite soil liners and drainage layers to minimize the potential release of contaminated leachate to the underlying Great Miami Aquifer.

The proposed disposal facility would be located on the northeast portion of the site, north of the former Production Area. This location is subject to change based upon the results of the detailed design process. The location was selected on the basis of the limited prior use of the area and the geologic conditions present on the area. Investigations in this area have identified a significant thickness of low permeability clay. Isolated silt and sand lenses within the clay in this area may be excavated or grouted in place to minimize the potential for vertical or horizontal movement of

groundwater underlying the disposal facility. Additional engineering controls, such as the installation of slurry walls, may also be required to preclude horizontal movement of groundwater beneath the disposal vault. The specific scope of the required engineering controls will be determined as part of detailed design.

Final closure would be completed by the construction of a multimedia cap over the vault. This cap would provide for a minimum 5 m (15 ft) cover over the disposed wastes. The cap would include a clay cover to eliminate radon emanation from the disposed wastes and a barrier to preclude intrusion by burrowing animals and hypothetical future residents of the area. Upon completion of the multimedia cap, security controls such as fencing would be installed. Monitoring wells would be appropriately located to evaluate the effectiveness of the above-grade disposal vault in ensuring the protection of human health and the environment. To provide added assurance against any future activities by man to intrude into the disposal vault, permanent markers would be installed to identify the vault and restrictions would be placed in the site deed. Additionally, the affected disposal areas at the FEMP would be placed under the perpetual ownership of the federal government. While the disposal vault would be designed to not require any continued active operations or maintenance, perpetual ownership would permit the government to continue to exercise its rights of ownership to preclude any development or drilling in areas where contaminated materials are disposed.

Remedial action activities under Alternative 2A/Vit could be completed in approximately six years. Construction, testing, and start-up of the material processing facility would require about three years. The treatment facility, which would operate concurrently with residue removal operations, would require about three years to complete the vitrification of the silo residues.

The total present worth cost of this alternative is estimated at 43.6 million dollars.

5.2.2 Alternative 2A/Cem - Removal, Cement Stabilization, and On-Property Disposal

Alternative 2A/Cem addresses the removal of the Silos 1 and 2 contents identical to the methods used in Alternative 2A/Vit, followed by cement stabilization of the K-65 residues and decant sump tank sludge, and on-property disposal of the treated material. After removal of the Silos 1 and 2 contents and decant sump tank sludge, the material would be pumped to an on-site processing facility for cement stabilization. The stabilized material would then be disposed of by the method proposed for Alternative 2A/Vit. Contaminated soil from the berms, structural materials from Silos 1 and 2, and debris generated through the cleanup and demolition of the hydraulic mining and cement stabilization systems would be managed under Subunit C. Because the treated material would remain on property under Alternative 2A/Cem, a review would be performed every five years in accordance with CERCLA to ensure the continued protection of human health and the environment.

Under Alternative 2A/Cem, approximately 6,796 m^3 (8,890 yd^3) of untreated wastes would be removed from the silos. Following treatment, approximately 18,166 m^3 (23,903 yd^3) of cement stabilized material would be placed in an on-property above-grade disposal vault.

The major components of this alternative include:

- Hydraulic Material Removal
- Cement Stabilization
- On-Property Disposal in an Above-Grade Disposal Vault
- Run-On/Runoff Control of Storm water
- Monitoring and Access Restrictions During Remedial Actions
- Monitoring and Continued Federal Ownership of the Disposal Area Following Remedial Actions
- CERCLA five-year Reviews

Alternative 2A/Cem would employ the use of the same site preparation, process facility, material removal, and on-property above-grade disposal vault options as previously discussed for Alternative 2A/Vit. However, Alternative 2A/Cem would use cement stabilization in place of vitrification as the treatment process option. Also, because cement stabilization results in a greater quantity of treated material than vitrification, the on-property above-grade disposal vault for the treated material is estimated to require 2.0 hectares (5 acres). With the installation of fencing and a buffer zone around the vault, up to 4.0 hectares (10 acres) would be required. Consistent with Alternative 2A/Vit, permanent markers would be installed to identify disposal areas and restrictions would be placed in the FEMP deed to preclude development and drilling. Further, the disposal vault at the FEMP site would continue under the perpetual ownership of the federal government to provide additional assurance that no development or drilling takes place in waste disposal areas.

Cement stabilization involves pumping the Silos 1 and 2 slurried contents and decant sludge through a screw feeder to a stabilization mixer. In the mixer, flyash, cement, and blast furnace slag are added with the appropriate amount of water. After the slurried K-65 residues are thoroughly mixed with the additives, the mixture would be pumped directly into disposal boxes and relocated to a nearby curing area. After the cement stabilized material has cured, it would be tested and transported to the above-grade disposal vault.

The cement stabilization facility would be straightforward to construct and reliable to operate. All of the necessary equipment is readily available because the process is widely used in the construction and mining industries; it has also been used frequently in hazardous material treatment applications. The necessary equipment has fully documented performance histories, so no significant problems or schedule delays are expected with regard to implementing this technology. Studies conducted on a small scale in a laboratory as part of the RI/FS indicate that an approximately 150 percent increase in the volume of waste requiring disposal following stabilization can be expected. This increase is a result of the required additives to support cement stabilization. These studies have also concluded that the cement stabilization of the wastes effectively reduces the radon emission rate from the waste and the tendency of the waste to leach contaminants into groundwater. The direct radiation associated with the untreated residues would be slightly reduced due to the effects of mixing the additives with the waste.

Remedial action activities under Alternative 2A/Cem could be completed in approximately six years. Material removal and treatment activities would require about three years. Approximately three years are projected for completion of site preparation, facilities construction, equipment installation, testing, and start-up of the material processing facility.

The total present worth cost of the alternative is estimated at 74.0 million dollars.

5.2.3 Alternative 3A.1/Vit - Removal, Vitrification, and Off-Site Disposal - Nevada Test Site

This alternative involves the removal, vitrification, and off-site disposal of the treated Silos 1 and 2 contents and decant sump tank sludge. This alternative is identical to Alternative 2A/Vit except that the on-property disposal, monitoring, and institutional controls have been replaced by transportation of the treated material off site. Treated material would be transported by rail or truck to the Nevada Test Site (NTS), a DOE-owned facility that currently accepts low-level radioactive material from DOE facilities for disposal. No five-year CERCLA reviews would be required under the alternative as no Subunit A waste would remain at the FEMP.

Under Alternative 3A.1/Vit, approximately 6,796 m^3 (8,890 yd^3) of untreated wastes would be removed from the silos. Approximately 2770 m^3 (3,645 yd^3) of vitrified material would be transported and disposed of at the NTS.

The major components of this alternative include:

- Hydraulic Material Removal
- Vitrification
- Monitoring and Access Restrictions During Remedial Actions

- Transportation
- Off-Site Disposal (NTS)

Alternative 3A.1/Vit would use the same site preparation/construction, residue removal, and material processing process options as Alternative 2A/Vit. The difference between these two alternatives is that Alternative 3A.1/Vit would dispose of the containerized treated residues off site at NTS.

Off-site disposal for this alternative involves the packaging, loading, and shipping of the treated material to the low-level radioactive disposal site at NTS. Currently, there are no direct rail lines to NTS. The treated material could be transported by rail to either a point near Las Vegas, Nevada, or one of the areas north of Las Vegas. From either location, the containers carrying the treated material would be transferred to trucks for transportation over roads to NTS.

NTS is located approximately 3219 kilometers (km) [2000 miles (mi)] from the FEMP site. It is currently in operation and it is assumed that NTS has both the resources and the capacity to accept any of the stabilized Operable Unit 4 material. Disposal at the NTS would be very effective at precluding contact with and contaminant migration from the treated residues from Subunit A. The FEMP site has an approved NTS waste shipment and certification program that is periodically audited by NTS. Efforts have been initiated to amend the current program to include Operable Unit 4 treated material.

Alternative 3A.1/Vit would be required to meet the U. S. Department of Transportation regulations pertaining to transportation of hazardous and radioactive materials. Additionally, all NTS waste acceptance requirements would need to be satisfied.

Remedial action activities under Alternative 3A.1/Vit could be completed in approximately six years. Material removal and treatment activities would require about three years. Approximately three years is projected for completion of site preparation, facilities construction, and equipment installation. Transportation and off-site disposal would conclude shortly after the completion of material processing.

The total present worth cost of this alternative is estimated at 42.2 million dollars.

5.2.4 Alternative 3A.1/Cem - Removal, Cement Stabilization, and Off-Site Disposal - NTS

This alternative is identical to Alternative 2A/Cem except that the on-property disposal, monitoring, and institutional controls have been replaced by transportation of the treated material off site. Treated material and debris would be transported by rail or truck to the NTS, a DOE-owned facility that currently accepts low-level radioactive material from DOE facilities for disposal. No five-year CERCLA reviews would be required as all Subunit A wastes would be removed from the site.

Under Alternative 3A.1/Cem, approximately 6,796 m^3 (8,890 yd^3) of untreated materials would be removed. Approximately 18,166 m^3 (23,903 yd^3) of cement stabilized product would be transported and disposed of at the NTS.

The major components of this alternative include:

- Hydraulic Material Removal
- Cement Stabilization of Wastes
- Monitoring and Access Restrictions During Remedial Action
- Transportation
- Off-Site Disposal (NTS)

This alternative would use the same site preparation/construction and removal processes as were discussed for Alternative 2A/Vit. The treatment process for this alternative is cement stabilization and would be the same as described for Alternative 2A/Cem. The off-site disposal at NTS would be the same as discussed in Alternative 3A.1/Vit. The volume of treated material to be disposed of would be higher than for the vitrification alternative.

Remedial action activities under Alternative 3A.1/Cem could be completed in about six years. Material removal and treatment activities would require about three years. Approximately three years are projected for completion of site preparation, facilities construction, and equipment installation. Transportation and off-site disposal would conclude shortly after the completion of material processing.

The total present worth cost of this alternative is estimated at 70.1 million dollars.

5.3 SUBUNIT B - CONTENTS OF SILO 3

5.3.1 Alternative 2B/Vit - Removal, Vitrification, and On-Property Disposal

This alternative requires the removal, vitrification, and on-property disposal of the Silo 3 contents. The silo contents would be removed with a pneumatic device introduced through the silo dome manways. This equipment would be supported by a work platform spanning the silo. The contents would then be pneumatically conveyed to a processing facility for vitrification. The containerized vitrified material would then be disposed of in an on-property above-grade disposal vault. The Silo 3 structural materials would be managed under Subunit C alternatives. Because the treated material would remain on property under Alternative 2B/Vit, a review would be performed every five years

by EPA in accordance with CERCLA to ensure the continued protection of human health and the environment. To provide added protection against potential intruder activities into disposed wastes, markers would be placed to identify the disposal facility, restrictions would be placed on the FEMP deed, and areas involving waste disposal would remain under the perpetual ownership of the federal government.

Under Alternative 2B/Vit, approximately 3,895 m^3 (5093 yd^3) of contaminated wastes would be removed from the silo. Approximately 1471 m^3 (1935 yd^3) of vitrified material would be placed in an on-property above-grade disposal facility. The on-property, above-grade disposal facility would cover approximately 1.0 hectares (2.5 acres). With fencing and buffer zones, approximately 2.6 hectares (6.5 acres) would be required for Alternative 2B/Vit.

The major components of this alternative include:

- Pneumatic Removal System
- Vitrification
- On-Property Disposal in an Above-Grade Disposal Vault
- Run-on/Runoff Control of Storm Water
- Monitoring and Access Controls During Remedial Actions
- Monitoring and Continued Federal Ownership of Disposal Areas at the FEMP Following Remedial Actions
- CERCLA Five-year Reviews

Alternative 2B/Vit would use the same site preparation/construction, material processing, and on-property above-grade disposal facility process options as Alternative 2A/Vit (Section 5.2.1). However, Alternative 2B/Vit would use pneumatic removal process option to transport Silo 3 contents to the material processing facility, due to the material characteristics.

The pneumatic removal system consists of a compressed air-driven pump that displaces and removes the dry wastes. This device would be suspended from an overhead structure. Pneumatic removal systems are readily available and requires a work platform, compressors, pumps, and intake and discharge lines.

Studies conducted as part of the RI/FS on a small scale in a laboratory indicate that vitrification can effectively reduce the tendency of the Silo 3 residues to leach inorganics and radionuclides to groundwater. This testing also demonstrated that over a 50 percent reduction in the volume of material requiring disposal could be realized through the application of vitrification technology to the Silo 3 residues.

The on-property disposal facility would be similar in design and location to that previously discussed for Alternative 2A/Vit. Refinements in this disposal facility concept may be implemented during the remedial design process to better accommodate the characteristics of the treated Silo 3 residues.

Remedial action activities under Alternative 2B/Vit could be completed in about four years. Site preparation and construction activities would take approximately three years. Removal activities would require about one year.

The total present worth cost of the alternative is estimated at 28.0 million dollars.

5.3.2 Alternative 2B/Cem - Removal, Cement Stabilization, and On-Property Disposal

This alternative uses the methodology presented in Alternative 2B/Vit, followed by treatment of the Silo 3 contents by cement stabilization, and on-property disposal of the stabilized material. After removal of the silo contents, the material would be pneumatically conveyed to a processing facility for cement stabilization and disposal. Because treated material would remain on property under Alternative 2B/Cem, a review would be performed every five years by EPA in accordance with CERCLA to ensure the continued protection of human health and the environment. Consistent with Alternative 2B/Vit, markers would be used to identify disposal areas, restrictions would be placed on the FEMP deed, and the federal government would retain perpetual ownership of disposal areas.

Under Alternative 2B/Cem, approximately 3895 m^3 (5093 yd^3) of contaminated materials would be removed from Silo 3. Approximately 5999 m^3 (7894 yd^3) of stabilized material would be placed in an on-property above-grade disposal facility. The Silo 3 structural materials and debris generated by the cleanup and demolition would be managed under the selected remedy for Subunit C.

The major components for this alternative include:

- Pneumatic Material Removal System
- Cement Stabilization
- On-Property Disposal in an Above-Grade Disposal Vault
- Run-On/Runoff Control of Storm Water

056

- Monitoring and Access Controls During Removal Actions
- Monitoring and Continued Federal Ownership of Disposal Areas at the FEMP Following Remedial Actions
- CERCLA Five-year Reviews

This alternative is identical to Alternative 2B/Vit, except that cement stabilization is used as the stabilization process option instead of vitrification. Due to the greater volume of the cement stabilized material (over 50 percent volume increase for cement stabilization versus greater than 50 percent volume decrease for vitrification), the on-property above-grade disposal vault would require 3.0 hectares (7.5 acres) instead of the 1.0 hectare (2.5 acres) for the vitrified material disposal. The site preparation/construction, material removal, and features of the above-grade disposal vault would be the same as for Alternatives 2A/Vit and 2B/Vit.

The cement stabilization process is identical to that described for Alternative 2A/Cem (Section 5.2.2) with the exception that cement, flyash, and blast furnace slag are added to the cold metal oxides following removal. Because the cold metals oxides and removal process are dry, water must be added to support cement stabilization. Studies conducted as part of the RI/FS on a small scale in a laboratory have projected that the cement stabilization of the Silo 3 residues will effectively control the potential for the leaching of inorganics and radionuclides from the treated waste form.

The on-property disposal vault would be similar in design to that previously discussed for Alternatives 2A/Vit. Refinements in this disposal vault concept may be implemented during the design process to better accommodate the characteristics of the treated Silo 3 residues.

Remedial action activities under Alternative 2B/Cem could be completed in about four years. Site preparation and construction activities would take approximately three years. Removal activities would require about one year.

The total present worth cost for this alternative is estimated at 37.4 million dollars.

5.3.3 Alternative 3B.1/Vit - Removal, Vitrification, and Off-Site Disposal - NTS

This alternative involves the removal, stabilization, and off-site disposal of the Silo 3 contents. This alternative is identical to Alternative 2B/Vit, except that the on-property disposal, monitoring, and institutional controls have been replaced by transporting the treated material by rail and/or truck to the NTS for disposal. Alternative 3B.1/Vit would have to meet applicable off-site requirements which include the NTS material acceptance criteria and the U. S. Department of Transportation regulations pertaining to the transport of hazardous and radioactive materials. No five-year reviews would be required as all Subunit B wastes would be removed from the site under this alternative.

Under Alternative 3B.1/Vit, approximately 3895 m^3 (5093 yd^3) of contaminated materials would be removed from the silo. Approximately 1471 m^3 (1935 yd^3) of vitrified material would be transported to and disposed of at the NTS.

The major components of this alternative include:

- Pneumatic Material Removal System
- Vitrification
- Monitoring and Access Controls During Remedial Actions
- Transportation
- Off-Site Disposal (NTS)

This alternative is identical to Alternative 2B/Vit (Section 5.3.1), except that the final disposal location of the containers of vitrified cold metal oxides would be at the NTS. The off-site disposal at NTS would be the same as discussed in Alternative 3A.1/Vit (Section 5.2.3).

Remedial action activities under Alternative 3B.1/Vit could to be completed in about four years. Site preparation and construction activities would take approximately three years. Removal activities would require about one year. Transportation and off-site disposal would conclude shortly after the completion of material processing.

The total present worth cost of this alternative is estimated at 26.7 million dollars.

5.3.4 Alternative 3B.1/Cem - Removal, Cement Stabilization, and Off-Site Disposal - NTS

This alternative is identical to Alternative 3B.1/Vit (Section 5.3.3), except that Silo 3 contents would be cement-stabilized prior to off-site disposal.

Under Alternative 3B.1/Cem, approximately 3895 m^3 (5093 yd^3) of contaminated materials would be removed from the silo. Approximately 5999 m^3 (7894 yd^3) of stabilized material would be transported and disposed of at the NTS.

The major components of this alternative include:

- Pneumatic Material Removal System
- Cement Stabilization

- Monitoring and Access Controls During Remedial Action
- Transportation
- Off-Site Disposal - (NTS)

Remedial action activities under Alternative 3B.1/Cem could be completed in about four years. Site preparation and construction activities would take approximately three years. Removal activities would require about one year. Transportation and off-site disposal would conclude shortly after the completion of material processing.

The total present worth cost of this alternative is estimated at 34.2 million dollars.

5.4 SUBUNIT C - SILOS 1, 2, 3, AND 4 STRUCTURES, SOILS, AND DEBRIS

5.4.1 Alternative 2C - Demolition, Removal, and On-Property Disposal

Alternative 2C involves the demolition of the Silos 1, 2, 3, and 4 structures and disposition of contaminated materials from the removal of the earthen berm, decant sump tank, process piping, and trenches. Alternative 2C further addresses the excavation of contaminated soils within the operable unit boundary and disposition of the contaminated debris generated as a result of implementing remedial actions for Subunits A and B. Contaminated material would be packaged and placed in an above-grade disposal vault at the FEMP site. Because material would remain on property under Alternative 2C, a review would be performed every five years by EPA in accordance with CERCLA to ensure the continued protection of human health and the environment.

Under Alternative 2C, approximately 24,634m^3 (32,214yd^3) of contaminated material would be placed in an on-property above-grade disposal vault, and approximately 30,280 liters (8,000 gallons) of decant sump tank water would be transported to the FEMP site's Advanced Wastewater Treatment facility.

The major components of this alternative include:

- Demolition
- Mechanical Removal of Rubble, Soil, and Piping
- Decontamination of Concrete, Piping, and Other Construction Materials
- Interim Storage of Soil and Debris (If Required)
- On-Property Disposal in an Above-Grade Disposal Vault
- Run-on/Run-off Control of Storm Water

- Monitoring and Access Controls During Remedial Action
- Monitoring and Continued Federal Ownership of Disposal Areas in Operable Unit 4 at the FEMP site
- CERCLA Five-year Reviews

Before Silos 1, 2, 3, and 4 are demolished, loose interior materials and loose concrete would be removed from the silo surfaces via high pressure water. The work platform used for the material removal would be used in this alternative to lower a robotic device, lighting, and video equipment into each silo interior via the dome manways.

The hydraulic pump would be used to remove the water and sediment produced from the pressure washing. The water would be sent to the FEMP Advanced Waste Water Treatment facility for treatment, and the concrete sediment would be packaged with the contaminated concrete from the subsequent concrete scabbling operation.

Silo demolition would consist of the systematic removal and dismantling of the Silos 1, 2, 3, and 4 domes, walls, and the Silo 3 floor slab and footer. The dome removal would involve using a diamond wire rope saw to cut each dome into manageable pieces after appropriate bracing has been installed. The demolition would begin with the dismantling of the Silo 4 dome, as this silo has never been used, making it an ideal full scale model to test and confirm demolition methodologies with minimal risk of radiological release to the environment. A crane would aid in the support of the dome sections during the cutting operation and would transport the sections to a concrete pad for size reduction with a diamond chain saw. The Silo 1 dome would be dismantled next followed by Silo 2. While the Silo 2 dome is being dismantled, a second crane would be used to aid in the dismantling and transfer of the Silo 1 wall sections to the pad. A diamond chain saw would be used to cut the walls into sections. After the Silo 2 dome is removed, one of the two cranes would be transferred to begin the dismantling of the Silo 3 dome, then Silo 4 dome. Demolition of the Silos 1 and 2 walls would continue with the remaining crane. Silos 3 and 4 would be demolished in a similar fashion to that of Silos 1 and 2.

After the sections of the silos are cut into manageable sections by a diamond chain saw, the sections would be transferred by a forklift to a temporary structure. The structure would house three vacuum scabbling machines. The scabbling machinery would be equipped with a vacuum system that is capable of packaging the contaminated concrete directly into disposal boxes. The purpose of scabbling would be to remove, if possible, the thickness of concrete containing the contamination to facilitate possible unrestricted release of clean portions. Scabbled, contaminated concrete from Silos 1 and 2, which exhibit highly elevated direct radiation fields, would be segmented from the other Subunit C wastes and dispositioned consistent with the selected remedy for Subunit A.

Contaminated piping, steel fencing, and other non-porous materials will be decontaminated, to the extent practical, using steam, acid washing, or other available treatment options. Non-porous materials attaining the unrestricted use, free release criteria defined in DOE Order 5400.5 would be released from the site as uncontaminated. The criteria within DOE Order 5400.5 are equivalent to criteria currently being employed by the Nuclear Regulatory Commission. Materials not attaining these levels would be retained for disposal as contaminated.

The volume of contaminated rubble and debris to be addressed under Operable Unit 4 represents a small fraction (less than one percent) of the total volume of similar wastes to be addressed under Operable Unit 3. Operable Unit 3 is currently in the process of conducting an RI/FS aimed at gaining additional insight into the effectiveness of various decontamination technologies on building materials. Additionally, the Operable Unit 3 RI/FS is evaluating the appropriate type and location of disposal for contaminated rubble and debris. The decision on the Operable Unit 3 RI/FS is presently scheduled at a time which coincides with the implementation of remedial actions for Operable Unit 4. Operable Unit 4 contaminated rubble and debris may be placed into interim storage to take full advantage of any forthcoming capabilities for waste minimization. Additionally, interim storage of Operable Unit 4 debris would allow the integration of disposal technologies for similar materials under Operable Unit 3. The design and management of interim storage facilities would be consistent with the approved Work Plan for FEMP Removal Action No. 17 - Improved Storage of Soil and Debris.

After the silos are demolished, the surface soils within the boundary of Operable Unit 4 would be excavated to attain proposed remediation levels for each of the constituents of concern. These cleanup levels are listed in Table 5-2. The concentration of each of these constituents which naturally occurs in local soils would be added to the levels listed in Table 5-2 to yield the final goals of the soil excavation process. Attainment of these levels would be demonstrated as an allowable average concentration over any 100-m^2 (120 yards) area across Operable Unit 4. Criteria for allowable "hot spots" within these areas will be defined as part of the remedial design process. These cleanup levels are considered protective of all reasonable future receptors, including hypothetical on-property residents. To attain these goals, a minimum of 15 cm (6 in) of soils across the entire operable unit area would be excavated. Additional soils beneath the silos, decant sump, concrete pipe trench, or other locations below this depth would be removed as necessary to attain these cleanup goals.

Soils exhibiting highly elevated direct radiation levels (i.e., potentially contaminated soils beneath Silos 1 and 2) will be segregated from other Subunit C wastes and dispositioned as part of the selected remedy for Subunit A. Following excavation, the affected areas will be returned to original grade with the placement of clean backfill and seeded.

It should be recognized that the volume of soils to be addressed under Operable Unit 4 represent less than one percent of the contaminated soils anticipated to be addressed on a site-wide basis by the

TABLE 5-2

PROPOSED REMEDIATION LEVELS IN SOILS

CONSTITUENTS	BACKGROUND CONCENTRATION	PROPOSED REMEDIATION LEVEL (ABOVE BACKGROUND)
Lead - 210[1]	1.33 pCi/g	5 pCi/g
Radium - 226[2]	1.45 pCi/g	4 pCi/g
Radium - 228[3]	1.19 pCi/g	5 pCi/g
Thorium - 228	1.43 pCi/g	5 pCi/g
Uranium - 238[1]	1.22 pCi/g	60 pCi/g
Antimony	7.7 mg/kg	7 mg/kg
Arsenic	8.45 mg/kg	16 mg/kg
Barium	91.3 mg/kg	128 mg/kg
Cadmium	0.82 mg/kg	3.2 mg/kg
Chromium (III)	15.5 mg/kg	316 mg/kg
Molybdenum	2.6 mg/kg	27 mg/kg
Nickel	20.9 mg/kg	166 mg/kg
Silver	2.6 mg/kg	4.8 mg/kg
Thallium	0.58 mg/kg	2.0 mg/kg
Vanadium	30.4 mg/kg	109 mg/kg
Zinc	62.2 mg/kg	42 mg/kg

[1]Includes two daughter products
[2]Includes five daughter products
[3]Includes one daughter product

remaining four FEMP site operating units. Operable Unit 5 is currently evaluating treatment options to potentially remove or significantly reduce the contaminants in the site soils. Pending the decision to employ such treatment facilities for site soils, Operable Unit 4 soils may be placed in interim storage at the FEMP site for a short duration to take full advantage of these forthcoming waste minimization capabilities. Interim storage facilities would be designed and managed consistent with the approved Work Plan for FEMP Removal Action 17 - Improved Storage of Soil and Debris.

The on-property disposal facility would be similar in design and location to that previously discussed for Alternative 2A/Vit. Refinements in this disposal facility concept may be implemented during the remedial design process to better accommodate the characteristics of the Subunit C wastes.

To provide added assurance of the continued protection of human health, markers would be placed to identify the disposal facility and areas containing residual levels of contamination in soils. Additionally, restrictions on drilling and development would be placed in the FEMP deed, and the portions of the property that contain waste disposal facilities and residual soil would be retained under the perpetual ownership of the federal government. While the disposal vault would be designed so as not to require active maintenance and the soil cleanup levels with the clean fill are protective of a hypothetical future on-property resident, these institutional controls provide additional certainty that these areas of the site will not be developed.

Water removed from the decant sump tank and Silo 4 (if any) would be sent to the FEMP Advanced Wastewater Treatment facility for treatment prior to discharge to the Great Miami River.

Approximately 3 months would be required for site preparation; 15 months would be required to demolish, decontaminate, and containerize the silo structures as well as the surface soil, berm soils, subsoils, process piping, and decant sump tank. Demobilization activities would extend the duration of the alternative to two years. During this time frame, the above-grade disposal facility would also be constructed and capped.

The total present worth cost of this alternative is estimated at 58.0 million dollars.

5.4.2 Alternative 3C.1 - Demolition, Removal, and Off-Site Disposal - NTS

This alternative is identical to Alternative 2C, except that the on-property disposal, monitoring, and institutional controls have been replaced by transporting the material by rail or truck to the NTS for disposal. Alternative 3C.1 would have to meet applicable off-site requirements, which include the NTS material acceptance criteria and the U. S. Department of Transportation regulations pertaining to the transport of hazardous and radioactive materials. CERCLA five-year reviews would be conducted by the EPA to ensure the remedial action continues to protect human health and the environment.

The major components of this alternative include:

- Demolition
- Mechanical Removal of Rubble, Soil, and Piping
- Decontamination of Concrete, Piping, and Other Construction Materials
- Monitoring and Access Controls During Remedial Actions
- Interim Storage of Soil and Debris (If Required)
- Transportation
- Off-Site Disposal (NTS)
- Monitoring and Perpetual Federal Ownership of Residual Contamination Areas at Operable Unit 4
- CERCLA Five-year Reviews

The off-site disposal option for Alternative 3C.1 involves the packaging, loading, and shipping of the contaminated material generated by this alternative to NTS (Section 5.2.3). The material to be disposed of would consist of silo rubble, building debris, and process equipment from the radon treatment system, berm soils, surface and subsoils, the decant sump tank, and process piping.

Under Alternative 3C.1, approximately 24,634 m^3 (32,214 yd^3) of contaminated material would be transported and disposed of at the NTS facility, and a volume of approximately 30,280 liters (8000 gallons) of decant sump tank water would be sent to the FEMP site's Advanced Wastewater Treatment facility.

Soil excavation under this alternative would continue until the soil and remediation levels previously identified in Table 5-2 are attained. Excavated soils will be containerized and shipped off site for disposal. Excavated areas will be backfilled with clean soils and seeded. While the cleanup levels, in conjunction with the clean soil backfill cover, do adequately protect all viable receptors, the areas containing the residual contamination will be marked, restrictions placed in the FEMP deed, and maintained under the perpetual ownership of the federal government. This continued federal ownership would permit the government to exercise its rights of ownership to preclude future site development in this area. This control would provide added assurance of the continued protection of any future inhabitants of the area.

Remedial actions for Alternative 3C.1 could require about two years to complete, including the transportation of the packaged materials to NTS.

The total present worth cost of this alternative is estimated at 59.5 million dollars.

5.4.3 Alternative 3C.2 - Demolition, Removal, and Off-Site Disposal (Permitted Commercial Disposal Site)

This alternative is identical to Alternative 3C.1, except that the off-site disposal at NTS has been replaced by the off-site disposal at a hypothetical permitted commercial disposal site. One such site is located near Clive, Utah, approximately 3058 km (1900 mi) from the FEMP site. The facility has been permitted by the State of Utah to accept mixed hazardous waste and is applying to receive authorization to accept naturally occurring by-product materials such as those in Subunit C.

The facility is currently in operation and would be capable of accepting waste from Subunit C in the future (following receipt of necessary state licensing). Due to its relatively long distance from the FEMP site, it would require coordination with several states for its transportation. Additionally, an exemption from DOE Order 5280.2A prohibiting disposal of DOE wastes at a commercial facility would be needed before waste could be transported to the disposal site.

The major components of this alternative include:

- Demolition
- Concrete Decontamination
- Mechanical Removal of Rubble, Soil, and Piping
- Monitoring and Access Controls During Remedial Actions
- Transportation
- Off-Site Disposal (Permitted Commercial Disposal Site)
- Monitoring and Continued Federal Ownership of the Areas Containing Residual Soil Contamination
- CERCLA Five-year Reviews

The off-site disposal option for Alternative 3C.2 involves the packaging, loading, and shipping of the contaminated material generated by this alternative to a permitted commercial disposal site. The material to be disposed of would consist of silo rubble, building debris, and process equipment from the radon treatment system, berm soils, surface and subsoils, the decant sump tank, and process piping.

Soil cleanup levels, free release levels for non-porous materials, and institutional controls, such as deed restrictions and continued federal ownership, would be consistent with Alternative 3C.1.

Under Alternative 3C.2, approximately 24,634 m^3 (32,214 yd^3) of contaminated material would be transported and disposed of at a permitted commercial disposal site, and a volume of approximately

32,280 liters (8,000 gallons) of decant sump tank water would be sent to the FEMP site's Advanced Wastewater Treatment facility.

Remedial actions for Alternative 3C.2 could require about two years to complete, including the transportation of the packaged materials to a permitted commercial disposal site.

The total present worth cost of this alternative is estimated at 82.4 million dollars.

6.0 EVALUATION OF ALTERNATIVES

6.1 EVALUATION CRITERIA

Specific legal requirements for remedial actions are specified under CERCLA Section 121, as amended. These requirements include protection of human health and the environment, compliance with ARARs, a preference for permanent solutions which use treatment as a principal element (to the maximum extent possible), and cost-effectiveness. To determine whether alternatives meet the requirements, EPA has identified nine criteria in the National Contingency Plan (EPA 1990) that must be evaluated for each alternative selected for detailed analysis. These criteria are:

1. Overall protection of human health and the environment
2. Compliance with applicable or relevant and appropriate requirements (ARARs)
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost
8. State acceptance
9. Community acceptance

The first two criteria are called threshold criteria because they relate directly to legal findings that must be made in the Record of Decision. Alternatives must meet these two criteria to be considered as final solutions. The factors reviewed under each of these two criteria are summarized below.

1. **Overall protection of human health and the environment:** Examines whether a remedy would provide adequate overall protection to human health and the environment. Evaluates how risks would be eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls included in the alternative.

2. **Compliance with ARARs:** Determines if a remedy would meet all pertinent environmental laws and policy siting requirements.

The next five criteria are grouped together as the primary balancing criteria under which the alternatives are evaluated. The factors reviewed under each of these five criteria are summarized below.

3. **Long-term effectiveness and permanence:** Evaluates the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup goals have been met.

4. **Reduction of toxicity, mobility, or volume through treatment:** Reviews the anticipated performance of the proposed treatment technologies for their abilities to reduce the hazards of, prevent the movement of, or reduce the quantity of waste materials.

5. **Short-term effectiveness:** Evaluates the ability of a remedy to achieve protection of workers, the public, and the environment during construction and implementation.

6. **Implementability:** Examines the practicality of carrying out a remedy, including the availability of materials and services needed during construction and operation.

7. **Cost:** Reviews both estimated capital and operation and maintenance costs of the remedy. Costs are presented as present worth costs. "Present worth" is defined as the amount of money that, if invested in the first year of implementing a remedy and paid out as needed, would be sufficient to cover all costs associated with the remedy over its planned life. Present worth costs allow remedies that would occur over different time periods to be compared on an even basis.

The final two criteria, **State Acceptance** and **Community Acceptance**, are called modifying criteria and will be considered following receipt of public comments on the Feasibility Study/Proposed Plan-Environmental Impact Study (FS/PP-EIS). These comments will be addressed in the Record of Decision document.

8. **State Acceptance:** Evaluates the technical and administrative issues and concerns the State of Ohio may have regarding each of the alternatives.

9. **Community Acceptance:** Evaluates the issues and concerns the public may have regarding each of the alternatives.

Consistent with the description in of Operable Unit 4 alternatives in Section 5.0 under each subunit, Section 6.2 compares the alternatives to one another under the EPA threshold and primary balancing criteria to identify their advantages and disadvantages. The alternatives comparison for each subunit is summarized in Table 6-1. The preferred remedial action alternative for each subunit is shown in boldface type. Only the no-action alternatives do not pass the threshold criteria. Section 6.3 identifies a preferred alternative for each subunit and combines those alternatives into the overall preferred alternative for Operable Unit 4. Section 6.3 also proposes considerations for integrating Operable Unit 4 remedial action with FEMP site-wide waste minimization efforts.

6.2 SUMMARY OF THE COMPARATIVE ANALYSIS OF ALTERNATIVES

The following sections summarize the information presented in Section 5.0 of the Feasibility Study Report for Operable Unit 4 and reply upon the detailed analysis of alternatives presented in Section 4.0 of the same report.

TABLE 6-1

COMPARISON OF REMEDIAL ALTERNATIVES

SUBUNIT A - SILOS 1 AND 2 CONTENTS

Alternative	Overall Protection of Human Health and Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility or Volume through treatment	Short-Term Effectiveness	Implementability	Total Present Worth Cost
0A - No Action	Not protective	Does not comply with all ARARs	Not effective or permanent	No treatment	High	Reliable technology, Easy	-0-
2A/Vit - Removal, Vitrification, On-Property Disposal	Protective[1]	Complies with all ARARs[2]	Effective and reliable	Reduces toxicity, mobility, and volume	Medium	Innovative technology, Moderate difficult	$43.6M
2A/Cem - Removal, Cement Stabilization, On-Property Disposal	Protective[1]	Complies with all ARARs[2]	Effective and reliable	Reduction of mobility	Medium	Reliable technology Easy	$74.0M
3A.1/Vit - Removal, Vitrification, Off-Site Disposal - Nevada Test Site	**Protective**	**Complies with all ARARs**	**Effective and most reliable**	**Reduces toxicity, mobility, and volume**	**Medium**	**Innovative technology, difficult**	**$42.2M**
3A.1/Cem - Removal, Cement Stabilization, Off-Site Disposal - Nevada Test Site	Protective	Complies with all ARARs	Effective and most reliable	Reduces mobility	Medium	Reliable technology, Difficult	$70.1M

690

4242

TABLE 6-1
(Continued)

SUBUNIT B - SILO 3 CONTENTS

Alternative	Overall Protection of Human Health and Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility or Volume through treatment	Short-Term Effectiveness	Implementability	Total Present Worth Cost
0B - No-Action	Not protective	Does not comply with all ARARs	Not effective or permanent	No treatment	High	Reliable technology, Easy	-0-
2B/Vit - Removal, Vitrification, On-Property Disposal	Protective[1]	Complies with all ARARs[2]	Effective and reliable	Reduces toxicity (organics), mobility, and volume	Medium	Innovative technology, Moderately Difficult	$28.0M
2B/Cem - Removal, Cement Stabilization, On-Property Disposal	Protective[1]	Complies with all ARARs[2]	Effective and reliable	Reduces toxicity and mobility	Medium	Reliable technology, Easy	$37.4M
3B.1/Vit - Removal, Vitrification, Off-Site Disposal - NTS	**Protective**	**Complies with all ARARs**	**Effective and most reliable**	**Reduces toxicity (organics), mobility, and volume**	**Medium**	**Innovative technology Difficult**	**$26.7M**
3B.1/Cem - Removal, Cement Stabilization, Off-Site Disposal - NTS	Protective	Complies with all ARARs	Effective and most reliable	Reduces toxicity and mobility	Medium	Reliable technology Difficult	$34.2M

TABLE 6-1
(Continued)

SUBUNIT C - SILOS 1, 2, 3, AND 4 STRUCTURES, SOILS, AND DEBRIS

Alternative	Overall Protection of Human Health and Environment	Compliance	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility or Volume through treatment	Short-Term Effectiveness	Implementability	Total Present Worth Cost
0C - No-Action	Not protective	Does not comply with all ARARs	Not effective or permanent	No treatment	High	Reliable technology, Easy	-0-
2C - Demolition, Removal, On-Property Disposal	**Protective[1]**	**Comply with all ARARs[2]**	**Effective and most reliable**	**No treatment**	**Medium**	**Reliable technology, Easy**	**$58.0M**
3C.1 - Demolition, Removal, Off-Site Disposal - Nevada Test Site	Protective	Complies with all ARARs	Effective and most reliable	No treatment	Medium	Reliable technology, Moderate difficult	$59.5M
3.C.2 - Demolition, Removal, Off-Site Disposal - Permitted commercial facility	Protective	Complies with all ARARs	Effective and most reliable	No treatment	Medium	Reliable technology, Moderate difficult	$82.4M

[1] -- Assessment of protectiveness adopts the use of continued federal goverment ownership and evaluates risk to recreational users and the off-property farmer.
[2] -- Assumes substantive technical requirements for Ohio disposal facility siting are met.
Bold -- Preferred Remedial Action Alternative
Shaded areas -- Did not meet threshold criteria (Overall Protection or Compliance with ARARs), therefore, not compared.
Protective -- Risk is within the one in ten thousand to one in a million USEPA target risk range

6.2.1 Subunit A

Five alternatives were compared for Subunit A, including a no-action alternative. Each alternative is listed below.

- Alternative 0A - No Action
- Alternative 2A/Vit - Removal, Vitrification, On-Property Disposal
- Alternative 2A/Cem - Removal, Cement Stabilization, On-Property Disposal
- Alternative 3A.1/Vit - Removal, Vitrification, Off-Site Disposal at NTS
- Alternative 3A.1/Cem - Removal, Cement Stabilization, Off-Site Disposal at NTS

The following sections compare the alternatives to one another using the nine EPA criteria.

6.2.1.1 Threshold Criteria

The analysis of the Subunit A alternatives against the threshold criteria of overall protection of human health and the environment and compliance with ARARs is summarized below.

Overall Protection of Human Health and the Environment. As part of the Feasibility Study two potential future land uses of the FEMP were evaluated to assess the ability of the individual alternative to adequately protect human health and the environment. Potential exposures to contaminants released during or following the implementation of the alternatives when evaluated to a range of viable receptors. These scenarios included future land use with and without the assumption of continued federal ownership. With continued government ownership, the FEMP land would not be available for residential or farming use. Access to the site would be limited by fencing and physical markers, so it would be reasonable to assume that a recreational user would visit the site occasionally. It is also assumed that the land surrounding the FEMP site would continue to be used for family farms. For a cleanup remedy to be considered protective, it should not result in any unacceptable risks to a recreational user or an off-property farmer. The evaluation also considers the future possibility that the federal government might lose control of the FEMP site. In that case, a farm might be established on the FEMP property. The remedial alternatives were evaluated as to what risks might exist for hypothetical on-property farmer if government control of the site is lost. The basis for and detailed results of these evaluations are in Appendix D of the Feasibility Study Report for Operable Unit 4.

The primary risks posed by the Subunit A materials are attributable to radon gas release from the material, direct radiation, and migration of constituents of concern to the air, soil, and groundwater. A remedial alternative should reduce or eliminate these risks for the recreational user, off-property farmer, and on-property farmer if government ownership is lost.

Alternative 0A (No-Action) would not provide adequate overall protection of human health and the environment. Alternative 0A would not eliminate, reduce, or control the potential health and environmental risks resulting from constituents in Subunit A materials. The Baseline Risk Assessment, presented in the Remedial Investigation Report for Operable Unit 4, showed that the no-action alternative would not be adequately protective. Movement of constituents to receptors would continue unchecked, and risks to human health and the environment could increase if current FEMP site access controls are removed.

All of the action alternatives would provide overall protection of human health and the environment. Alternatives 3A.1/Vit and 3A.1/Cem would provide overall protection because the Subunit A residues would be treated and removed to the NTS. The source of risks to the recreational user and off-property farmer would be eliminated. In the event that the government lost control of the FEMP site, there would be no risk from Subunit A residues to an on-property farmer. These alternatives would also be protective of environmental receptors such as wildlife and biota inhabiting surface water. Overall protection at the NTS would be maintained because the vitrified or cement stabilized residues resist leaching. In addition, the NTS is located in a sparsely populated, arid region, where depths to groundwater range are up to 600 m (2000 ft).

Alternatives 2A/Vit and 2A/Cem would also use treatment to immobilize the Subunit A residues. The treated material would then be placed in an on-property above-grade disposal vault. The vault would include features that control radon emissions, prevent direct radiation contact, and greatly slow movement of constituents to groundwater. On-property disposal would be protective of the recreational user, the off-property farmer, and the Great Miami Aquifer over the long term. The disposal vault and treated residue form would also be protective of an on-property farmer if the government lost control of the site. The disposal vault would include a barrier and physical markers that would discourage the on-property farmer from penetrating it and coming in contact with the residues. Fate and transport modeling demonstrates that protectiveness would be maintained at any point in the Great Miami Aquifer if the on-property farmer installed a well.

In summary, Alternatives 3A.1/Vit and 3A.1/Cem would provide the greatest degree of overall protection because they would remove the Subunit A residues from the FEMP site.

Compliance with ARARs. CERCLA requires that remedial actions achieve a standard or level of control that is consistent with environmental laws or facility siting regulations, which are termed applicable or relevant and appropriate requirements (ARARs). ARARs apply to all aspects of remedial action, including the establishment of cleanup levels, the operation and performance of treatment systems, and the design of disposal facilities. In addition to meeting ARARs, operations at DOE-owned facilities must be conducted according to DOE Orders. Although DOE Orders are not promulgated laws, the technical requirements may be adapted if they cover areas not addressed by other laws, or if they improve protection of human health and the environment because they are more

stringent than existing laws. Detailed discussion of compliance with ARARs is provided in Appendix F of the Feasibility Study Report for Operable Unit 4.

There are three types of ARARs:

(a) Chemical-specific ARARs include: specific limits (maximum contaminant levels [MCLs]) on contaminants in drinking water; specific limits on air emissions of radon and other radionuclides; and residual concentrations of certain radionuclides in soil.

(b) Location-specific ARARs include: limitations on performing certain activities because of geographic, hydrologic, or land use concerns.

(c) Action-specific ARARs include: specifications for certain types of operations and design requirements for disposal facilities.

Alternative 0A (No Action) would not comply with a number of chemical-specific, location-specific, and action-specific ARARs. Under the no-action alternative, Silos 1 and 2 would eventually fail, resulting in the release of the contents to the environment. This scenario would likely result in radiological releases to the air, soil, groundwater, and surface water (via storm water runoff). For example, fate and transport modeling for this scenario indicates that the safe drinking water limits (MCLs in 40 CFR 141) would be exceeded for uranium, and gross alpha and beta radiation.

All of the Subunit A action alternatives would meet all pertinent ARARs. There is one location-specific ARAR which is significant for all on-property disposal alternatives (including those for Subunits A, B, and C). There is also one action-specific ARAR which is significant only for the on-property disposal for treated Subunit A materials. These will be highlighted as part of the evaluation summary for Alternative 2A/Vit and 2A/Cem which follows.

Alternatives 2A/Vit and 2A/Cem would meet all pertinent chemical-specific ARARs. In the short term, on-property remediation activities during removal and treatment would control airborne emissions, releases to the soil, and direct radiation exposure by engineered controls. Under these two alternatives, the containerized treated residues would be placed in an on-property disposal vault designed to control releases to the air, soil, and groundwater. These design features would contain the Subunit A residues to control direct radiation, prevent the release of radon into the air, and minimize leachate production and migration into the groundwater. Fate and transport modeling was conducted using very conservative assumptions for the generation of leachate. Conservative assumptions included increased rates of rainwater moving through the vault cap to come into contact with the residues, increased release of constituents from the residues, and increased rate of release of leachate through the vault liner. The modeling results, simulating a 1,000-year time period, indicate

that drinking water limits (MCLs) would not be exceeded at any point in the Great Miami Aquifer underlying the FEMP site.

All surface water releases (via the vault leachate collection/detection system) would be directed to the FEMP Advanced Wastewater Treatment facility for treatment and release, within the requirements established by the FEMP National Pollutant Discharge Elimination System (NPDES) permit issued by the State of Ohio.

Alternatives 2A/Vit and 2A/Cem would comply with all pertinent location-specific ARARs, including those related to the construction of the vitrification or cement stabilization treatment facility. OAC Rule 3745-27-07(B)(5), which prohibits the construction of a new solid waste disposal facility over a sole- source aquifer, is a significant ARAR for the on-property disposal alternatives. The Great Miami Aquifer is a designated sole-source aquifer. The OAC rule does provide for exemptions if certain technical criteria pertaining to hydrogeology are met. Major considerations include whether a significant thickness [minimum 5 m (15 ft)] of low permeable material exists between the disposal facility liner and the sole-source aquifer, and whether there is an interconnection between the sole-source aquifer and any significant saturated zones which exist above the sole-source aquifer. It must also be demonstrated that no adverse impact occurs to human health and safety or the environment.

The available data for the proposed location of the on-property above-grade disposal vault meets the technical requirements to support the basis for an exemption. On-property disposal of materials resulting from remedial actions would be considered waste consolidation activities. The disposal vault would not be a new facility and a formal exemption would not be required. However, the technical requirements for an exemption must be demonstrated. The data show that there is a significant thickness of low permeable glacial till above the Great Miami Aquifer at the proposed disposal vault location. Pockets of more permeable till mixed with silt and sand were occasionally encountered. They are not extensive, nor are they interconnected to the Great Miami Aquifer in the area proposed. Final design considerations for the disposal vault would include plans for excavating and/or grouting the more permeable pockets underneath the disposal vault liner to further retard potential leachate migration. The fate and transport modeling mentioned previously in Section 6.2.1.1 also demonstrates that human health and environmental protection would be maintained.

With respect to the other location-specific ARARs, the planned construction of the on-property disposal vault would incorporate the requirements for the environmental and wetlands/floodplain regulations. Specifically, a mitigation plan would be required to compensate for any proposed disturbance of streams and wetlands (40 CFR 6.302).

Alternatives 2A/Vit and 2A/Cem would comply with all pertinent action-specific ARARs. The waste treatment (vitrification or cement stabilization), packaging, and transportation of Subunit A material would be operated to protect workers (direct radiation and radon gas) and the public (radon emissions).

The disposal vault system incorporates the design requirements for the disposal of uranium mill tailings (40 CFR 192) and for hazardous waste under Resource Conservation And Recovery Act (RCRA) (40 CFR 264). The following features would be incorporated into the overall design: waste treatment (vitrification/cement stabilization); engineered concrete vault with intruder barrier; multi-layer leachate collection/detection system; and a 3-meter (10 ft) thick multimedia cap.

An action-specific ARAR particular to on-property disposal of Subunit A material at the FEMP site is 40 CFR 191 (Standards for the Management, Storage and Disposal of Spent Nuclear, High Level and Transuranic Waste). In October 1990, EPA directed DOE to consider 40 CFR 191 Subpart A (dealing with the storage and management of waste) as "relevant and appropriate" to the on-site portions of remedial activities involving the K-65 residues, and to consider Subpart B (pertaining to waste disposal) as an additional requirement.

40 CFR 191 Subpart A specifies a public dose limit that is to be complied with during waste storage and remedial operations. Estimates of the dose to the public, calculated for the short-term risk assessment, indicate that exposures would be a small fraction of the one mrem/year limit (see Appendix D of the Feasibility Study Report for Operable Unit 4).

40 CFR 191 Subpart B sets forth containment requirements for which the disposal vault system must be designed to provide a reasonable expectation that specified cumulative radionuclide-specific release limits would not be exceeded for 10,000 years. In order to demonstrate compliance with such a requirement, a probabilistic assessment of all events that could result in a release of waste material from the disposal vault would need to be undertaken, along with an assessment of the impact that each identified release would have on the accessible environment. On this basis, the likely compliance of Alternatives 2A/Vit and 2A/Cem could not be assessed. In a January 1991 letter, EPA questioned the application of these release limits to the on-site disposal alternatives but repeated their concern about the need to provide for the long-term protection of inadvertent intruders for 10,000 years. All other provisions of 40 CFR 191 would be attained by these alternatives.

Alternatives 3A.1/Vit and 3A.1/Cem would comply with all pertinent chemical-specific ARARs. With off-site disposal at NTS, there would be no long-term compliance issues associated with the FEMP site. For example, off-site disposal would eliminate the need to demonstrate that drinking water MCLs are attained for Subunit A residues. In the short-term, the on-property remediation activities during removal and treatment would address the operational requirements for airborne emissions, soil pathways, and penetrating radiation by engineered controls.

Alternatives 3A.1/Vit and 3A.1/Cem include construction of the on-property waste treatment facility for either vitrification or cement stabilization and would comply with all location-specific ARARs.

Alternatives 3A.1/Vit and 3A.1/Cem would comply with all pertinent action-specific ARARs. In particular, the packaging and transportation of the treated waste would be accomplished with the requirements for the protection of worker and public safety from the radiological hazards (49 CFR 171-177). This alternative would also comply with other off-site requirements, such as Waste Acceptance Criteria specified by NTS, to meet their disposal requirements.

In summary, Alternatives 2A/Vit, 2A/Cem, 3A.1/Vit, and 3A.1/Cem would meet all pertinent ARARs. Because of the uncertainty associated with demonstrating that the FEMP on-property disposal vault would provide for the long-term protection of inadvertent intruders from Subunit A residues for 10,000 years, Alternatives 3A.1/Vit and 3A.1/Cem are favored over 2A/Vit and 2A.Cem. The probability of an inadvertent intruder coming in contact with the Subunit A residues at NTS is less than that for the FEMP site, based on the demographic characteristics of both locations.

6.2.1.2 Primary Balancing Criteria

Those alternatives which satisfy the threshold criteria comparative analysis were carried forward to the primary balancing criteria for further comparative analysis. Because Alternative 0A (No Action) did not satisfy either of the threshold criteria, it is not considered further in this analysis. Those alternatives carried forward were:

- Alternative 2A/Vit - Removal, Vitrification, and On-Property Disposal
- Alternative 2A/Cem - Removal, Cement Stabilization, and On-Property Disposal
- Alternative 3A.1/Vit - Removal, Vitrification, and Off-Site Disposal at NTS
- Alternative 3A.1/Cem - Removal, Cement Stabilization, and Off-Site Disposal at NTS

Long-Term Effectiveness and Permanence. All Subunit A action alternatives would ensure long-term protectiveness to human health and the environment. For all alternatives projected FEMP site residual risks to viable receptors (off-property farmer and recreational user) would be less than a 10^{-6} incremental lifetime cancer risk, and no non-carcinogenic effects (hazard index less than 0.2) would be indicated for either receptor.

All alternatives involve the removal and treatment of Subunit A residues by either vitrification or cement stabilization. Treatability studies conducted on the Subunit A materials demonstrated that vitrification would be effective in reducing radon emanation and in minimizing the leaching of constituents. Tests using cement stabilization demonstrated that this process would also be effective in preventing the movement of constituents from the stabilized form. The vitrified material is expected to have greater durability over the long term, because the vitrification process is essentially irreversible. Tests on the cement-stabilized form indicated that this process is not irreversible.

Alternatives 2A/Vit and 2A/Cem would place the treated Subunit A residues in an on-property, above-grade disposal vault. Alternatives 3A.1/Vit and 3A.1/Cem would transport the treated materials off site to the NTS. For the reasons previously described in Section 6.2.1.1, off-site disposal of treated Subunit A residues is favored over on-property disposal. The characteristics of the NTS would provide greater certainty over the long term that the treated residues would not affect human health and the environment.

Long-term environmental impacts associated with construction of the on-property, above-grade disposal vault for Alternatives 2A/Vit and 2A/Cem include permanent disruption of up to 5.8 hectares (14 acres) of land. No significant long-term impacts would be expected for water quality, air quality, socioeconomic, or cultural resources. Long-term impacts as a consequence of committing approximately 4.0 hectares (10 acres) to residue disposal at NTS would be minor.

In summary, Alternatives 3A.1/Vit and 3A.1/Cem would provide a greater degree of long-term effectiveness than alternatives 2A/Vit and 2A/Cem.

Reduction of Toxicity, Mobility, or Volume through Treatment. Alternatives 2A/Vit and 3A.1/Vit would use the vitrification process to treat the Subunit A material. This technology would physically bind the contaminants in a glass-like matrix which would significantly reduce contaminant mobility and material volume. Mobility would be reduced because the contaminants would be bound in the matrix and the volume of the treated material would be less than 50 percent of the untreated material volume. Vitrification would also destroy organic contaminants in the treated material. Although most contaminants in the treated material would be incorporated into the vitrified product to reduce mobility over the long term, some contaminants would be released during the vitrification process and must be treated through an off-gas treatment system. The material generated through the off-gas treatment system may require stabilization to limit subsequent contaminant mobility.

Alternatives 2A/Cem and 3A.1/Cem would use the cement stabilization process to treat contaminated material. This technology will physically and chemically bind the constituents in a cement-like matrix, so the mobility of constituents via leaching from this treated material would be greatly reduced. However, organic constituents would not be destroyed. The total volume of material would increase by approximately 150 percent as a result of adding the cement stabilizing and setting agents.

In summary, Alternatives 2A/Vit and 3A.1/Vit are favored over Alternatives 2A/Cem and 3A.1/Cem because they would: reduce the toxicity of organic contaminants; generate a treated form which has greater resistance to leaching; and, reduce the volume of Subunit A materials.

Short-Term Effectiveness. For Subunit A action alternatives, the various removal, treatment, and disposal activities will result in increased short-term risks for exposures (compared to no action). The short-term effectiveness of the removal operations is expected to be the same among all alternatives

for Subunit A. There is some uncertainty associated with controlling and treating the off-gases generated by the vitrification process.

For the on-property alternatives (2A/Vit and 2A/Cem), short-term disruption of land for the disposal vault construction would result in minor impacts to biota and wetlands [0.36 hectares (0.9 acres)]. Proper engineering controls would minimize these impacts.

For the off-site alternatives (3A.1/Vit and 3A.1/Cem), there would be increased risks from transportation accidents; greater risks would be associated with cement stabilization because the increased volume of the treated material would increase the number of trips. Short-term impacts at the NTS associated with the transportation and off-loading of treated residues would be minor.

The time required to implement any of the removal and treatment alternatives is estimated to be approximately six years.

In summary, Alternatives 2A/Cem and 3A.1/Cem are favored over Alternatives 2A/Vit and 3A.1/Vit because of the uncertainty associated with off-gas control and treatment for the vitrification process.

Implementability. The removal and treatment activities in Alternatives 2A/Cem and 3A.1/Cem could be implemented using standard equipment, procedures, and readily available resources. Hydraulic removal is a standard mining technology that is normally reliable and uses readily available equipment. The cement stabilization technology has been applied successfully at a number of remedial sites. EPA considers cement stabilization a demonstrated treatment technology and has approved its use in the final remedy for many National Priorities List sites. This technology has also been applied at other sites that are radioactively contaminated. The cement stabilization process would require large quantities of cement, flyash, and blast furnace slag, which are available.

Although removal and disposal are the same for Alternative 2A/Vit as for Alternative 2A/Cem and Alternative 3A.1/Vit as for Alternative 3A.1/Cem, the vitrification process is more difficult to implement than the cement stabilization process. The vitrification process would require fewer chemical reagents than for the cement stabilization process, but larger amounts of energy (electricity). Vitrification would facilitate the re-processing of off-specification treated materials compared to cement stabilization. In addition, the vitrification process equipment would be more complex to construct and operate than that of the cement stabilization process. There is limited experience available for the types and quantities of the material from the silos and decant sump tank on which to base an assessment of the likely performance of the vitrification technology. The vitrification technology is not as widely available as the cement stabilization technology. Off-gas treatment is also an additional complexity with vitrification where delays could occur. However, operational experience is being gained as part of the structured RI/FS treatability studies and planned vitrification pilot studies currently in progress.

Alternatives 2A/Vit and 2A/Cem would require an on-property, above-grade disposal vault. Construction of the disposal vault would be readily implemented using standard construction procedures and materials. Alternatives 3A.1/Vit and 3A.1/Cem involve off-site transportation and disposal at the NTS. While technically straightforward, off-site transportation would require coordination efforts with a number of states located along the transportation route, as well as the State of Nevada. A Waste Certification Acceptance Program, specific to the NTS, for Subunit A materials would be required prior to shipping.

In summary, Alternatives 2A/Cem and 3A.1/Cem would be favored over Alternatives 2A/Vit and 3A.1/Vit, based on relative overall implementing.

Cost. The estimated total present worth costs for Subunit A alternatives are provided on Table 6-2, and include a breakdown of capital and operating and maintenance costs.

Alternative 3A.1/Vit is the least expensive action alternative. The present worth cost of Alternative 2A/Vit is approximately $1.4 million higher than that of Alternative 3A.1/Vit. This is due to the higher cost of construction of an on-property above-grade disposal vault as compared to off-site transportation and disposal at NTS. Alternatives 3A.1/Cem and 2A/Cem are approximately 66 percent and 75 percent more expensive, respectively, than Alternative 3A.1/Vit. The alternatives that include cement stabilization are more expensive than vitrification alternatives, primarily due to the additional packaging, transportation, and disposal for the large volume of cement-stabilized material.

6.2.1.3 Subunit A Comparative Analysis Summary

On the basis of the comparative analysis of Subunit A alternatives, Alternative 3A.1/Vit is identified as the preferred alternative. This alternative is cost-effective and would result in the permanent treatment and volume reduction of Subunit A materials. It would provide overall protection of human health and the environment with fewer uncertainties over the long-term.

6.2.2 SUBUNIT B

Five alternatives were compared for Subunit B, including a no-action alternative. Each alternative is listed below.

- Alternative 0B - No Action
- Alternative 2B/Vit - Removal, Vitrification, and On-Property Disposal
- Alternative 2B/Cem - Removal, Cement Stabilization, and On-Property Disposal
- Alternative 3B.1/Vit - Removal, Vitrification, and Off-Site Disposal at NTS

TABLE 6-2
OPERABLE UNIT 4 REMEDIAL ALTERNATIVE COST SUMMARY (MILLION$)

ALTERNATIVE	CAPITAL	OPERATING & MAINTENANCE		TOTAL PRESENT WORTH COST
		SHORT-TERM (During Remediation)	LONG-TERM (Post Remediation)	
Subunit A - Silos 1 and 2 Contents				
OA - No Action	0	0	0	0
2A/Vit - Removal, Vitrification, On-Property Disposal	36.5	11.7	3.4	43.6
2A/Cem - Removal, cement Stabilization, On-Property Disposal	71.2	11.7	3.6	74.0
3A.1/Vit - Removal, Vitrification, Off-Site disposal - Nevada Test Site	36.6	11.7	0	42.2
3A.1/Cem - Removal, Cement Stabilization, Off-Site Disposal - Nevada Test Site	68.5	11.7	0	70.1
Subunit B - Silo 3 Contents				
OB - No Action	0	0	0	0
2B/Vit - Removal, Vitrification, On-Property Disposal	25.2	4.9	3.2	28.0
2B/Cem - Removal, Cement Stabilization, On-Property Disposal	35.9	4.9	3.2	37.4
3B.1/Vit - Removal, Vitrification, Off-Site Disposal - Nevada Test Site	25.2	4.9	0	26.7
3B.1/Cem - Removal, Cement Stabilization, Off-Site Disposal - Nevada Test Site	34.7	4.1	0	34.2
Subunit C - Silos 1, 2, 3, and 4 Structures, Soils, and Debris				
0C - No Action	0	0	0	0
2C - Demolition, Removal, On-Property Disposal	62.6	0	3.6	58.0
3C.1 - Demolition, Removal, Off-Site Disposal - Nevada Test Site	65.8	0	0	59.5
3C.2 - Demolition, Removal, Off-Site Disposal - Permitted commercial facility	91.2	0	0	82.4

NOTES:
The accuracy of the cost estimates are between +50% and -30%.
Estimates of Capital and Operating & Maintenance Costs are expressed in terms of total costs. The total present worth costs are calculated from the total cost figures applying a discount rate of 7.0% and an Operating & Maintenance period of 30 years.

- Alternative 3B.1/Cem - Removal, Cement Stabilization, and Off-Site Disposal at NTS

6.2.2.1 Threshold Criteria

Subunit B alternatives would employ the same removal, treatment, and disposal options as those for Subunit A materials. Many of the factors considered and discussed under the Subunit A analysis are identical for Subunit B. Therefore, frequent references will be made to the information presented previously in Section 6.2.1. Only those factors unique to remediation of the Subunit B materials will be emphasized. This approach will be applied to the discussions under the primary balancing criteria as well.

The comparison of the Subunit B alternatives against the threshold criteria of overall protection of human health and the environment and compliance with ARARs is summarized below.

Overall Protection of Human Health and the Environment. As discussed in Section 6.2.1.1, this evaluation assumes that the federal government would continue to own the FEMP site. For a cleanup remedy to be considered protective, it should not result in any unacceptable risks to a recreational user or an off-property farmer.

The risks posed by the Subunit B materials are direct radiation, radon gas emission, and migration of constituents of concern to the air, soil, and groundwater.

Alternative 0B (No Action) will not provide adequate overall protection of human health and the environment. Alternative 0B will not eliminate, reduce, or control the health or environmental risks resulting from constituents in Subunit B materials. The Baseline Risk Assessment presented in the Remedial Investigation Report for Operable Unit 4, showed that the no-action alternative would not be adequately protective. Movement of constituents to receptors would continue unchecked, and risks to human health and the environment could increase if current FEMP site access controls are removed.

The removal and treatment alternatives would provide overall protection of human health and the environment. Alternatives 2B/Vit, 2B/Cem, 3B.1/Vit, and 3B.1/Cem would limit exposure to contaminants by removing the material, treating the material by either vitrification or cement stabilization, and then disposing the treated material in an on-property above-grade disposal vault (Alternatives 2B) or off site at NTS (Alternatives 3B.1). Long-term effectiveness would be attained for each of these alternatives.

Off-property disposal would provide a greater degree of protectiveness than on-property disposal for the same reasons discussed under this criterion for Subunit A. For Subunit B residues the inadvertent intruder to the on-property, above-grade disposal vault would not be exposed to levels of direct radiation as high as those for Subunit A residues.

In summary, Alternatives 3B.1/Vit and 3B.1/Cem would provide the greatest degree of overall protection because they would remove the Subunit B residues from the FEMP site.

Compliance with ARARs. Alternative 0B (No Action) would not comply with a number of chemical-specific, location-specific, and action-specific ARARs. Under the no-action alternative, Silo 3 would eventually fail, resulting in the release of cold metal oxides to the environment. This scenario would likely result in radiological releases to the air, soil, groundwater, and surface water (via storm water runoff). For example, fate and transport modeling for this scenario indicates that the safe drinking water limits (MCLs in 40 CFR 141) would be exceeded for uranium, and gross alpha and beta radiation.

Subunit B action alternatives would comply with all pertinent chemical-specific, location-specific, and action-specific ARARs, similar to the discussions for Subunit A.

Two ARARs would be of particular significance to Subunit B alternatives involving on-site disposal (Alternative 2B/Vit and 2B/Cem).

First, OAC Rule 3745-27-07(B)(5) is a location-specific ARAR which prohibits the construction of a new solid waste disposal facility over a sole-source aquifer. A exemption may be granted on the basis of meeting certain technical requirements. As presented in Section 6.2.1.1, available data for the proposed location of the disposal vault on the FEMP site would satisfy the requirements. Further, the on-site disposal operations would involve consolidation of materials, rather than new facility construction.

Second, the action-specific requirements of 40 CFR 191, which would be applied to Subunit A materials, would not apply to Subunit B residues. The design requirements for 40 CFR 192 would be apply to Subunit B.

The off-site alternatives (3B.1/Vit and 3B.1/Cem) would meet all pertinent ARARs. For example, ARARs pertaining to drinking water MCLs would not be pertinent because the Subunit B residues would be removed from the FEMP site.

In summary, Alternatives 2B/Vit, 2B/Cem, 3B.1/Vit, and 3B.1/Cem would meet all pertinent ARARs. Because the uncertainty associated with demonstrating that the FEMP on-site disposal vault would provide for the long-term protection of inadvertent intruders, Alternatives 3B.1/Vit and 3B.1/Cem are favored over 2B/Vit and 2B/Cem.

6.2.2.2 Primary Balancing Criteria

Those alternatives that satisfy the threshold criteria comparative analysis were carried forward to the primary balancing criteria comparative analysis. Because Alternative 0B (No Action) did not satisfy

either of the threshold criteria, it is not considered further in this analysis. Those alternatives carried forward were:

- Alternative 2B/Vit - Removal, Vitrification, and On-Property Disposal
- Alternative 2B/Cem - Removal, Cement Stabilization, and On-Property Disposal
- Alternative 3B.1/Vit - Removal, Vitrification, and Off-Site Disposal at NTS
- Alternative 3B.1/Cem - Removal, Cement Stabilization, and Off-Site Disposal at NTS

Long-Term Effectiveness and Permanence. All Subunit B alternatives would ensure long-term protectiveness to human health and the environment. For all alternatives, projected FEMP site residual risks to viable receptors (off-property farmer and recreational uses) would be less than 10^{-6} incremental lifetime cancer risk, and no non-carcinogenic effects (hazard index less than 0.2) would be indicated for either receptor.

The characteristics of the treated residue form (vitrification or cement stabilization) and the disposal options (on site or off site at NTS) are similar to those discussed under long-term effectiveness for Subunit A materials. Long-term environmental impacts are also the same as those considered for Subunit A.

In summary, Alternatives 3B.1/Vit and 3B.1/Cem provide a greater degree of long-term effectiveness than Alternatives 2B/Vit and 2B/Cem.

Reduction of Toxicity, Mobility, or Volume through Treatment. Alternatives 2B/Vit and 3B.1/Vit would use the vitrification process to treat the Subunit B material. This technology would physically bind the contaminants in a glass-like matrix, which would significantly reduce contaminant mobility and material volume. Mobility would be reduced since the contaminants would be bound in the matrix and the volume of the treated material would be approximately 62 percent of the untreated material volume.

Alternatives 2B/Cem and 3B.1/Cem would use the cement stabilization process to treat the Subunit B material. This technology will physically and chemically bind the constituents in a cement-like matrix, so the mobility of constituents (via leaching from) in this treated material would be greatly reduced. However, organic constituents would not be destroyed, and the total volume of material will increase by 55 percent as a result of adding the cement stabilizing and setting agents.

In summary, Alternatives 2B/Vit and 3B.1/Vit are favored over Alternatives 2B/Cem and 3B.1/Cem because they would generate a treated form which has greater resistance to leaching and would reduce the volume of the Subunit B materials.

Short-Term Effectiveness. For the Subunit B action alternatives, the various removal, treatment, and disposal activities would result in increased short-term risks (compared to no action). The short-term effectiveness of removal operations is expected to be the same among all alternatives for Subunit B. There is some degree of uncertainty associated with controlling and treating the off-gases generated by the vitrification process.

The increased risks due to off-site transportation of the treated residues to NTS and the short-term environmental impacts associated with removal, treatment, and disposal are similar to those described in Section 6.2.1.2.

In summary, Alternatives 2B/Cem and 3B.1/Cem are favored over Alternatives 2B/Vit and 3B.1/Vit because of the uncertainty associated with off-gas control and treatment for the vitrification process.

The time required to implement either treatment alternative is six years.

Implementability. The removal and treatment activities for all Subunit B action alternatives could be implemented with standard equipment, procedures, and readily available resources. Pneumatic removal would be employed for the Subunit B materials and it is a standard technology that is typically reliable and uses readily available equipment. All other aspects of implementing the action alternatives for Subunit B are identical to those discussed for Subunit A under the implementability criterion in Section 6.2.1.2.

In summary, Alternatives 2B/Cem and 3B.1/Cem would be favored over Alternatives 2B/Vit and 3B.1/Vit based on relative overall implementability.

Cost. The estimated total present worth costs for Subunit B Alternatives are provided in Table 6-2 and include a breakdown of capital and operating and maintenance costs.

Alternative 3B.1/Vit is the least expensive action alternative. The present worth cost of Alternative 2B/Vit is approximately 1.3 million dollars higher than that of Alternative 3B.1/Vit. This is due to the higher cost of constructing an on-property, above-grade disposal vault as compared to off-site transportation and disposal at NTS. Alternatives 3B.1/Cem and 2B/Cem are approximately 31 percent and 39 percent more expensive, respectively, than Alternative 3B.1/Vit. Alternative 3B.1/Cem is more expensive than Alternative 3B.1/Vit primarily due to the additional packaging, transportation, and disposal of the cement-stabilized material.

6.2.2.3 Subunit B Comparative Analysis Summary

On the basis of the comparative analysis of the Subunit B alternatives, Alternative 3B.1/Vit is identified as the preferred alternative. This alternative is cost-effective and would result in the permanent treatment and volume reduction of Subunit B materials. Alternative 3B.1/Vit would

provide overall protection of human health and the environment with fewer uncertainties over the long-term.

6.2.3 Subunit C

Four alternatives were compared for Subunit C, including a no-action alternative. Each alternative is listed below.

- Alternative 0C - No Action
- Alternative 2C - Demolition, Removal, On-Property Disposal
- Alternative 3C.1 - Demolition, Removal, Off-Site Disposal at NTS
- Alternative 3C.2 - Demolition, Removal, Off-Site Disposal at a Permitted Commercial Disposal Site

6.2.3.1 Threshold Criteria

The analysis of the Subunit C alternatives against the threshold criteria of overall protection of human health and the environment and compliance with ARARs is summarized below.

Overall Protection of Human Health and the Environment. Alternative 0C would not provide adequate protection of human health and the environment. As discussed in Section 6.2.1.1, evaluations were conducted for future land uses with and without continued federal ownership. For a cleanup remedy to be considered protective, it would not result in any unacceptable risks to a recreational user or an off-property farmer under the future land use with continued federal ownership scenario.

The primary risks posed by Subunit C materials are potential exposures due to direct contact with contaminated soil and debris, exposure to direct radiation, and migration of contaminants to the air, surface soil, and groundwater.

All of the action alternatives (Alternatives 2C, 3C.1, and 3C.2) would limit exposure to constituents by decontaminating, demolishing, and removing the material to either an on-property above-grade disposal facility or off-site disposal facility, and then excavating contaminated soils and placing clean fill over residual contaminated subsurface soils. Table 5-2 summarizes the proposed soil cleanup levels, all of which would be protective to the residential user and off-site resident over the long term. Short-term risks would be higher for off-site disposal due to the increased risk of transportation accidents.

The basic difference among the action alternatives is the disposal option. On-property disposal (Alternative 2C) would be in an above-grade disposal facility. Off-site disposal options include NTS (Alternative 3C.1) and a permitted commercial disposal site (Alternative 3C.2).

The on-property, above-grade disposal facility design would be designed for a 1,000 year life with no active maintenance. Fate and transport modeling using conservative assumptions concludes that protectiveness would be maintained over the long term.

NTS and the commercial disposal facility would incorporate engineering controls to ensure protectiveness. Both are located in a climatic, demographic, and hydrogeologic setting which favors minimization of constituent migration to human or environmental receptors.

In summary, Alternatives 3C.1 and 3C.2 would provide the greatest degree of overall protection because they would remove the Subunit C excavated soils and debris from the FEMP site.

Compliance with ARARs. Alternative 0C (No Action) would not comply with a number of chemical-specific, location-specific, and action-specific ARARs. Under the no-action alternative, it would be likely that constituents would continue to be released to the air, groundwater, and surface water. There would also be a risk for direct contact with contaminated soil and exposure to direct radiation. For example, residual, localized "hot spots" could exceed the limits established in 40 CFR 192.12.

Alternative 2C would comply with all pertinent chemical-specific, location-specific, and action-specific ARARs. Two ARARs would be of particular significance to Alternative 2C.

First, OAC rule 3745-27-07(B)(5) is a location-specific ARAR which prohibits the construction of a new solid waste disposal facility over a sole-source aquifer. An exemption may be granted on the basis of meeting certain technical requirements. As presented in Section 6.2.1.1, available data for the proposed location of the disposal facility on the FEMP site would satisfy the requirements. Further, the on-site disposal operations would involve consolidation of materials, rather than new facility construction.

Second, the material associated with Subunit C poses fewer hazards than the material in Subunits A and B. Therefore, the on-property, above-grade disposal facility would require less stringent engineering design requirements to meet the provisions of 40 CFR 192.

The off-site alternatives (3C.1 and 3C.2) would meet all pertinent ARARs. The demolition, decontamination, soil excavation, and packaging of contaminated soil and debris would be carried out in compliance with all requirements designed to protect the public and workers.

In summary, Alternatives 2C, 3C.1, and 3C.2 would meet all pertinent ARARs.

6.2.3.2 Primary Balancing Criteria

Those alternatives that satisfy the threshold criteria of compliance with ARARs and overall protection of human health and environment were carried forward to the primary balancing criteria comparative analysis. Because Alternative 0C (No Action) did not satisfy either of the threshold criteria, it is not considered further in this analysis. Those alternatives carried forward were:

- Alternative 2C - Demolition, Removal, On-Property Disposal
- Alternative 3C.1 - Demolition, Removal, Off-Site Disposal at Nevada Test Site
- Alternative 3C.2 - Demolition, Removal, Off-Site Disposal at Permitted Commercial Facility

Long-Term Effectiveness and Permanence. All Subunit C alternatives would ensure long-term protectiveness to human health and the environment. For all alternatives, projected FEMP site residual risks to viable receptors (off-property farmer and recreational user) would be less than 10^{-6} incremental lifetime cancer risk and no non-carcinogenic effects (hazard index less than 0.2) would be indicated for either receptor. Although residual contamination would remain in the Operable Unit 4 Study Area, the level of risk from the contaminated soil would be controlled by excavating soil that exceeds proposed cleanup levels and by placing clean soil over the excavated areas.

Alternative 2C would employ an on-site disposal facility designed to minimize leachate generation from water infiltration and contact with contaminated soil and debris. Fate and transport modeling using conservative assumptions demonstrates that both risk- and ARAR-based protective levels would be maintained for the Great Miami Aquifer over the long term.

Alternatives 3C.1 (NTS) and 3C.2 (permitted commercial disposal site) would provide long-term protectiveness because the residual soils and debris would be removed from the FEMP site. The institutional controls and adequate facility maintenance are likely to be more reliable at NTS, as it is a DOE-owned facility.

Following completion of remedial operations, impacted areas would be restored; long-term environmental impacts are expected to be minor. Alternative 2C would result in permanent dedication of approximately 4.7 hectares (11.6 acres) of land for the disposal facility.

In summary, Alternatives 3C.1 and 3C.2 would provide a greater degree of long-term effectiveness than Alternative 2C.

Reduction of Toxicity, Mobility, or Volume through Treatment. Alternatives 2C, 3C.1 and 3C.2 will isolate the material from the environment by containment. Treatment of the contaminated silo structures, berm material, or soils is not included in any of the alternatives. Volume reduction would

be achieved by scabbing the surface of contaminated concrete and segregating the cleans material for the scabbled material.

Short-Term Effectiveness. For the action alternatives (Alternatives 2C, 3C.1 and 3C.2), the various demolition and removal activities would result in increased short-term exposures compared to no action. Alternatives 3C.1 and 3C.2 would pose additional risks to the public and workers associated with off-site shipment to NTS or the permitted commercial disposal facility.

During the implementation of any of the action alternatives, the general public is not likely to be exposed to contaminants because of the distance from the work area, the very low levels of contamination, and the methods proposed to control dust during demolition.

Potential short-term environmental impacts resulting from the implementation of Alternatives 2C, 3C.1, and 3C.2 include generation of fugitive dust, increased sediment in surface runoff, and disturbance and/or displacement of wildlife as a result of noise, dust, and human activity. Engineering controls would be used to minimize these potential short-term impacts.

All Subunit C action alternatives would require approximately two years to complete.

In summary, Alternative 2C is favored over Alternatives 3C.1 and 3C.2. The short-term risks to the public and workers for constructing the on-site disposal facility would offset the increased risks to the public and workers associated with off-site transportation of the contaminated soils and debris.

Implementability. Alternatives 2C, 3C.1, and 3C.2 would all employ the same decontamination, demolition, and excavation operations. With the exception of the remotely controlled operations proposed for decontaminating Silos 1, 2, and 3, all operations are standard construction activities which would be easily implemented. The remote silo decontamination operations would be used on the uncontaminated Silo 4 first to improve worker familiarity and identify any potential operational difficulties.

Alternative 2C involves on-site disposal facility construction, which would employ standard construction services and materials. The off-site disposal alternatives (3C.s and 3C.2) would involve standard transportation practices.

Alternatives 3C.1 and 3C.2 would be more difficult to implement than Alternative 2C from an administrative perspective due to the coordination required with those states through which shipment would pass to the off-site locations. Additional efforts would be required to ensure that the Subunit C materials complied with criteria established by either NTS or the permitted commercial disposal facility. Alternative 2C would require coordination with the State of Ohio to ensure that all technical requirements for the on-site disposal facility were met.

In summary, Alternative 2C is favored over Alternatives 3C.1 and 3C.2 based on relative overall implementability.

Cost. The estimated total present worth costs for Subunit C alternatives are provided in Table 6-2, and include a breakdown of capital and operating and maintenances cost.

Alternative 2C is less expensive than Alternative 3C.1 by approximately $1.5 million. This is mostly because the on-property above-grade disposal facility is less costly than transporting and disposing of the material at the NTS. The overall cost of disposal at a permitted commercial disposal facility would be approximately 40 percent higher than the cost of disposal at a DOE facility. The unit cost for disposal at a DOE-owned facility is approximately 30 percent of that for the commercial facility.

6.2.3.3 Subunit C Comparative Analysis Summary

On the basis of the comparative analysis of the Subunit C alternatives, Alternative 2C is identified as the preferred alternative. This alternative is cost-effective and would provide overall protection of human health and the environment over the long-term, and would eliminate the increased risks and costs associated with off-site transportation and disposal.

6.3 IDENTIFICATION OF THE PREFERRED REMEDIAL ALTERNATIVE FOR OPERABLE UNIT 4

The comparative analysis in Section 6.2 summarized the relative advantages and disadvantages, in accordance with CERCLA criteria, of each of the alternatives for the three Operable Unit 4 subunits. At the conclusion of each subunit analysis, a preferred alternative for Subunit A, Subunit B, and Subunit C was identified in Sections 6.2.1.3, 6.2.2.3, and 6.2.3.3, respectively.

The preferred alternatives initially selected were:

Subunit A: Alternative 3A.1/Vit - Removal, Vitrification, and Off-site Disposal - NTS

Subunit B: Alternative 3B.1/Vit - Removal, Vitrification, and Off-site Disposal - NTS

Subunit C: Alternative 2C - Demolition, Removal, and On-Property Disposal

Because Subunit C involves the management of soils and debris, DOE has considered other FEMP site-wide factors in assembling an overall preferred remedial alternative for Operable Unit 4. Of particular significance is the fact that the volumes of soil and debris in Subunit C are only a small fraction of the volumes of soil and debris that must be addressed as part of the entire FEMP site cleanup.

DOE believes that the disposition of the Subunit C materials should be integrated with the larger volumes of similar soil and debris. Accordingly, the initially preferred alternative for Subunit C will be modified to incorporate an integration strategy. Figure 6-1 illustrates the combination of the subunit alternatives into the overall preferred remedial alternative for Operable Unit 4. Section 6.3.1 presents the considerations and strategy for integrating the Subunit C materials with site-wide waste management activities. Section 6.3.2 describes the overall preferred remedial alternative for Operable Unit 4, incorporating the integration strategy for Subunit C materials.

Sections 6.3.3 and 6.3.4 summarize environmental and ecological risk factors associated with implementing the preferred alterative.

6.3.1 Considerations for FEMP Site-wide Waste Management Integration

As previously discussed in Section 3.0 of this Proposed Plan, the operable unit concept has been adopted at the FEMP site to address the management of similar types of wastes using similar approaches to remedial action. The identification of Operable Unit 4 as a discrete waste management area of the FEMP site resulted primarily from the nature and configuration of the materials in Silos 1, 2, and 3.

The preferred alternative for Operable Unit 4 would utilize vitrification to treat the materials of Subunits A and B (contents of Silos 1, 2, and 3) for final disposal off site. The remaining Operable Unit 4 materials, Subunit C, include residual soils which have been contaminated by the contents of Subunits A and B. They also include the structural debris which would result from the demolition of the silos, associated structures, and vitrification processing facility once treatment has been completed. The Operable Unit 4 Feasibility Study Report addresses the Subunit C materials as a remaining source of contamination. The previously identified preferred alternative incorporates final disposition of the soils and debris in an on-property above-grade disposal facility, as described above.

Currently, two other FEMP site operable units are in the process of evaluating remedial alternatives for contaminated soils and debris. By definition, Operable Unit 5 will develop, evaluate, and propose a final remedial alternative to address, on a site-wide basis, contaminated environmental media, including soils. Similarly, Operable Unit 3 will propose a final remedial alternative for the debris, including structural concrete, steel, and process piping, which will result from the decontamination and dismantling of the former Production Area facilities.

Operable Unit 5 has already initiated pilot-scale soil washing operations on the basis of earlier bench-scale tests which yielded promising results for this technology. The soil washing process involves treating contaminated soils with a reagent (e.g., acid) which extracts soil contaminants in solution and reduces contaminant concentration in the soils. The extract is recovered and reduced in volume for appropriate disposal. Based on the efficiency of the process, the washed soils (which represent the largest fraction of the treated material) may be suitable for disposal in a less restrictive manner, based

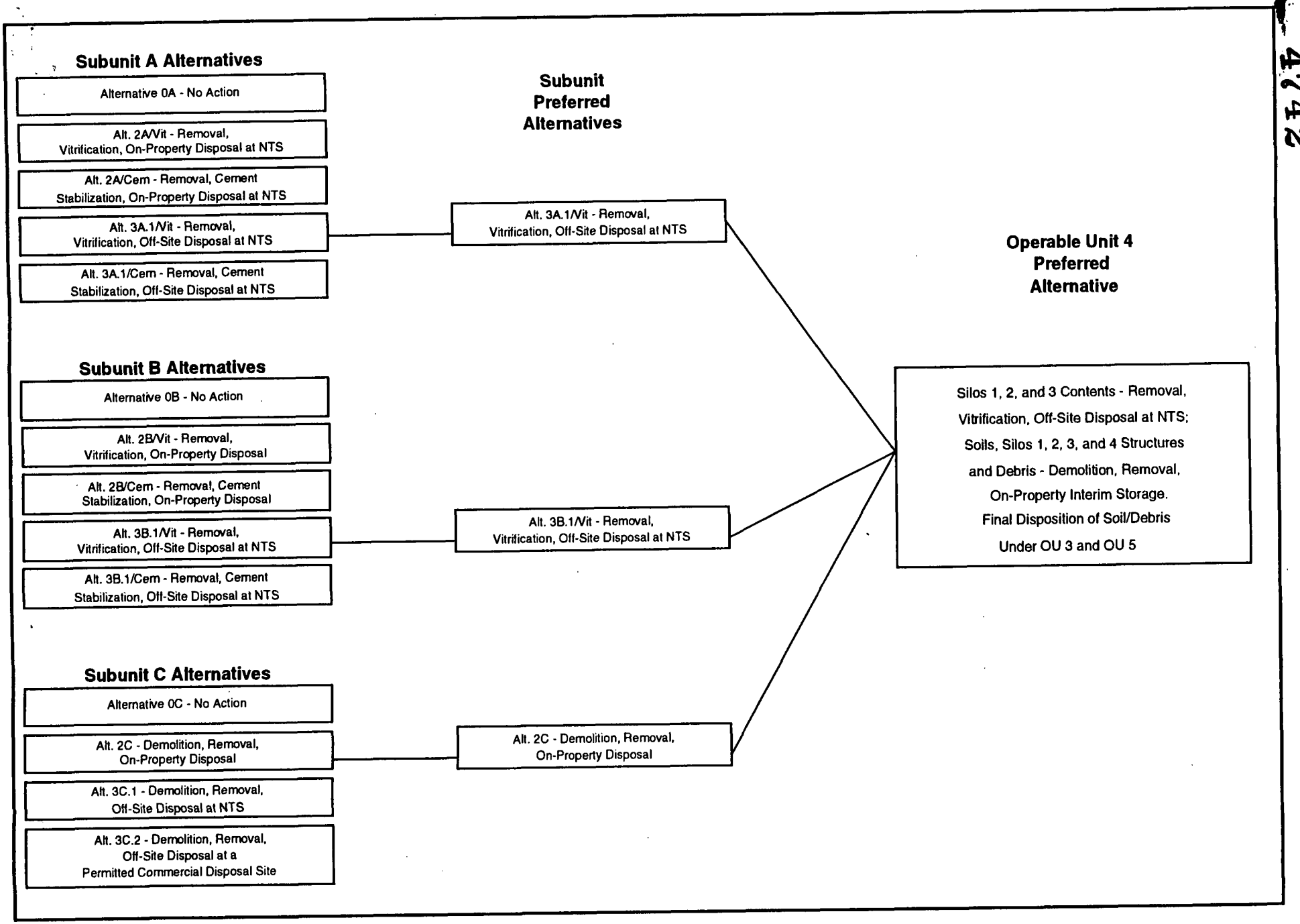

Subunit A Alternatives
Alternative 0A - No Action
Alt. 2A/Vit - Removal, Vitrification, On-Property Disposal at NTS
Alt. 2A/Cem - Removal, Cement Stabilization, On-Property Disposal at NTS
Alt. 3A.1/Vit - Removal, Vitrification, Off-Site Disposal at NTS
Alt. 3A.1/Cem - Removal, Cement Stabilization, Off-Site Disposal at NTS
Subunit B Alternatives
Alternative 0B - No Action
Alt. 2B/Vit - Removal, Vitrification, On-Property Disposal
Alt. 2B/Cem - Removal, Cement Stabilization, On-Property Disposal
Alt. 3B.1/Vit - Removal, Vitrification, Off-Site Disposal at NTS
Alt. 3B.1/Cem - Removal, Cement Stabilization, Off-Site Disposal at NTS
Subunit C Alternatives
Alternative 0C - No Action
Alt. 2C - Demolition, Removal, On-Property Disposal
Alt. 3C.1 - Demolition, Removal, Off-Site Disposal at NTS
Alt. 3C.2 - Demolition, Removal, Off-Site Disposal at a Permitted Commercial Disposal Site
Subunit Preferred Alternatives
Alt. 3A.1/Vit - Removal, Vitrification, Off-Site Disposal at NTS
Alt. 3B.1/Vit - Removal, Vitrification, Off-Site Disposal at NTS
Alt. 2C - Demolition, Removal, On-Property Disposal
Operable Unit 4 Preferred Alternative
Silos 1, 2, and 3 Contents - Removal, Vitrification, Off-Site Disposal at NTS; Soils, Silos 1, 2, 3, and 4 Structures and Debris - Demolition, Removal, On-Property Interim Storage. Final Disposition of Soil/Debris Under OU 3 and OU 5

FIGURE 6-1

on estimated residual risk. The approach is designed to minimize the volume of waste eventually requiring more restrictive and expensive containment or disposal. The total volume of soil which might be treated by Operable Unit 5 is estimated to be several million cubic yards. A large-scale soil washing facility is currently in the preliminary design stage. Based on current schedules for remedial actions for Operable Unit 5, this facility could be operational by 1998.

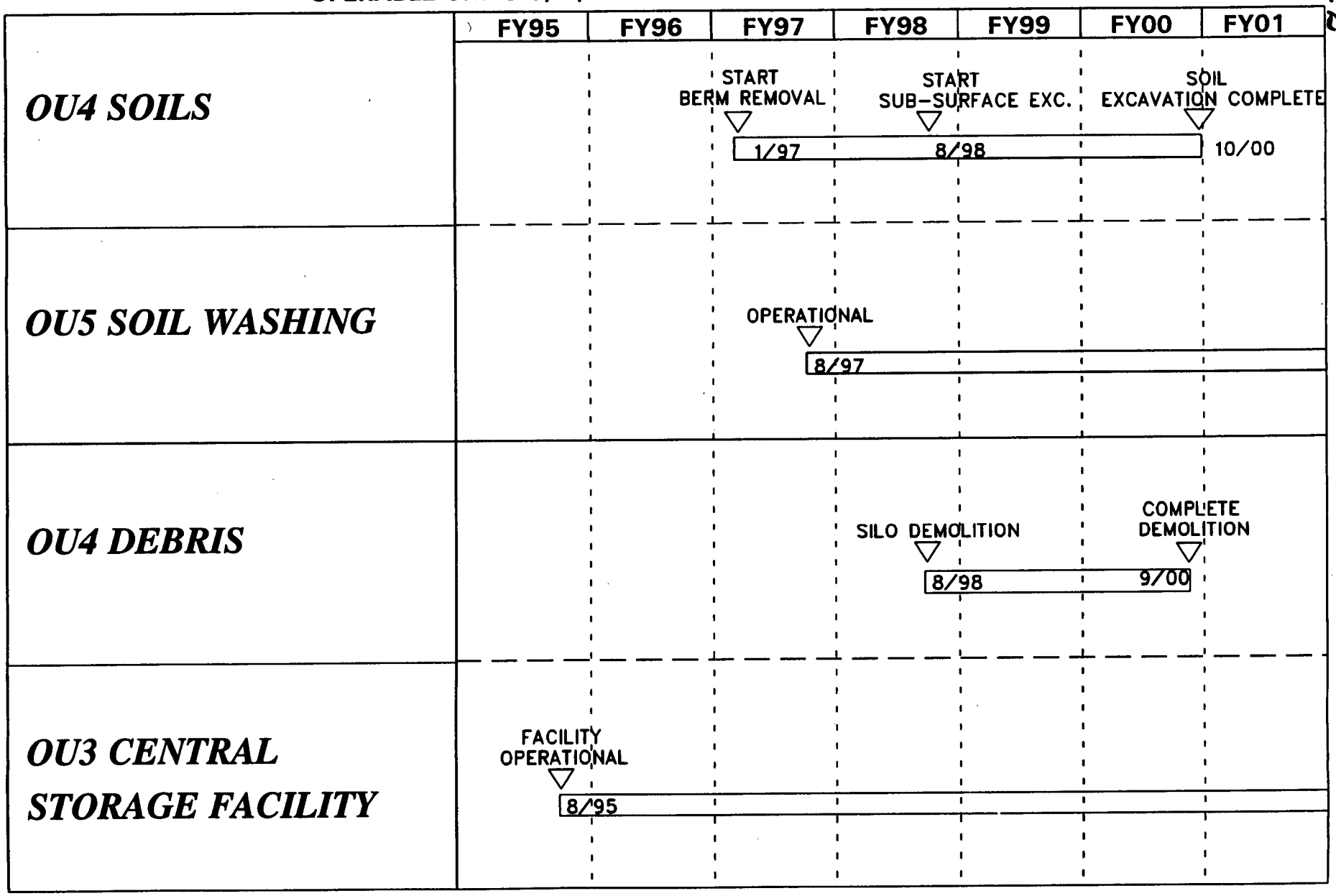
Likewise, Operable Unit 3 has initiated a removal action (Removal Action 17) to manage debris resulting from decontamination and dismantling activities. An engineered Central Storage Facility, to contain contaminated debris from production facility dismantling prior to disposition, is nearing final design. A Remedial Investigation and Feasibility Study is underway to evaluate various alternatives for decontamination and free-release, disposal, or recycling of contaminated structural debris. The total volume of material to be managed by Operable Unit 3 is also estimated to be several million cubic yards.

The estimated volume of contaminated soils and structural debris comprising Operable Unit 4 Subunit C materials is less than one percent of the Operable Unit 5 soil volume and less than one percent the Operable Unit 3 debris volume.

In the interest of coordinating site-wide cleanup efforts at the FEMP and to fulfill the statutory preference of CERCLA for waste treatment and volume reduction, it is proposed that the decision regarding the type and location of the final disposition of the Operable Unit 4 soil and debris be placed in abeyance to facilitate the proper integration of this decision with forthcoming decisions for Operable Units 3 and 5. The integration would be achieved by placing in interim storage the soils and debris resulting from the implementation of the Operable Unit 4 preferred alternative. Interim storage would be conducted in accordance with the EPA-approved Work Plan for Removal Action 17. The final disposition of the Operable Unit 4 materials would occur coincidental to the implementation of the Records of Decision for Operable Units 3 and 5. This strategy would promote cost-savings through reduction of volumes requiring disposal and would realize economies-of-scale through treatment by processes developed for larger volumes of soil and debris.

The current remedial action implementation schedules for Operable Units 3, 4, and 5 would favor this proposed approach. Figure 6-2 shows the key milestones for coordination. Operable Unit 4 soil excavation would be initiated in January 1997, approximately six months before the Operable Unit 5 soil washing plant is scheduled to go on line. The duration of Operable Unit 4 soil excavation extends to the year 2000 due to the required sequence for removal and treatment of the silo contents. Thus, there would be ample time for Operable Unit 5 to optimize the washing process to accommodate Operable Unit 4 soils. The Operable Unit 3 Central Storage Facility will be operational nearly five years before the Operable Unit 4 remedial action sequence leads to silo and processing facility decontamination and dismantling. By then, it is expected that Operable Unit 3 would have made significant progress in decontamination and recycling technology.

FIGURE 6-2
OPERABLE UNITS 3, 4, AND 5 COORDINATION SCHEDULE



The overlapping remedial action schedules for Operable Units 3, 4, and 5 provide an excellent opportunity to integrate FEMP site-wide cleanup activities in a manner consistent with CERCLA preferences for treatment, minimization of land disposal, and cost-effectiveness.

In the event that coordination efforts become infeasible for technical reasons, the soil and debris would be dispositioned in accordance with the on-property disposal alternative based on the Feasibility Study for Operable Unit 4. Since the completion of soil and debris removal is near the end of the Operable Unit 4 preferred alternative implementation sequence, there would be sufficient time to initiate the on-property disposal facility construction, which can be completed in about 18 months.

6.3.2 Description of Preferred Remedial Alternative for Operable Unit 4

To address the overall remediation of Operable Unit 4, the preferred alternatives for each of the subunits are combined to form the preferred remedial alternative for Operable Unit 4. The alternative initially preferred by DOE and identified in Figure 6-1, consists of the following major components:

- Removal of the contents of Silos 1, 2, and 3 (K-65 residues and cold metal oxides) and the decant sump tank sludge.

- Vitrification (glassification) of the residues and sludges removed from the silos and decant sump tank.

- Off-site shipment for disposal at the NTS of the vitrified contents of Silos 1, 2, 3, and the decant sump tank.

- Demolition of Silos 1-4 and decontamination, to the extent practical, of the concrete rubble, piping, and other generated construction debris. Unrestricted release of materials demonstrated to attain free-release criteria.

- Removal of the earthen berms and excavation of contaminated soils within the boundary of Operable Unit 4, to achieve proposed remediation levels. Placement of clean backfill following excavation.

- Demolition of the vitrification treatment unit and associated facilities. Decontamination or recycling of debris prior to disposition. Unrestricted releases of materials demonstrated to attain free-release criteria.

- On-property interim storage of excavated contaminated soils and remaining contaminated debris in a manner consist with the approved Work Plan for Removal Action 17 (improved storage of soil and debris).

- Continued access controls and maintenance and monitoring of the stored wastes inventories.

- Potential additional treatment of stored Operable Unit 4 Inventories using Operable Unit 3 and 5 waste treatment systems.

- Place in abeyance the final decision regarding the final disposition of remaining Operable Unit 4 contaminated soils and debris

- Disposal of remaining Operable Unit 4 contaminated soils and debris consistent with the selected remedies for Operable Units 3 and 5.

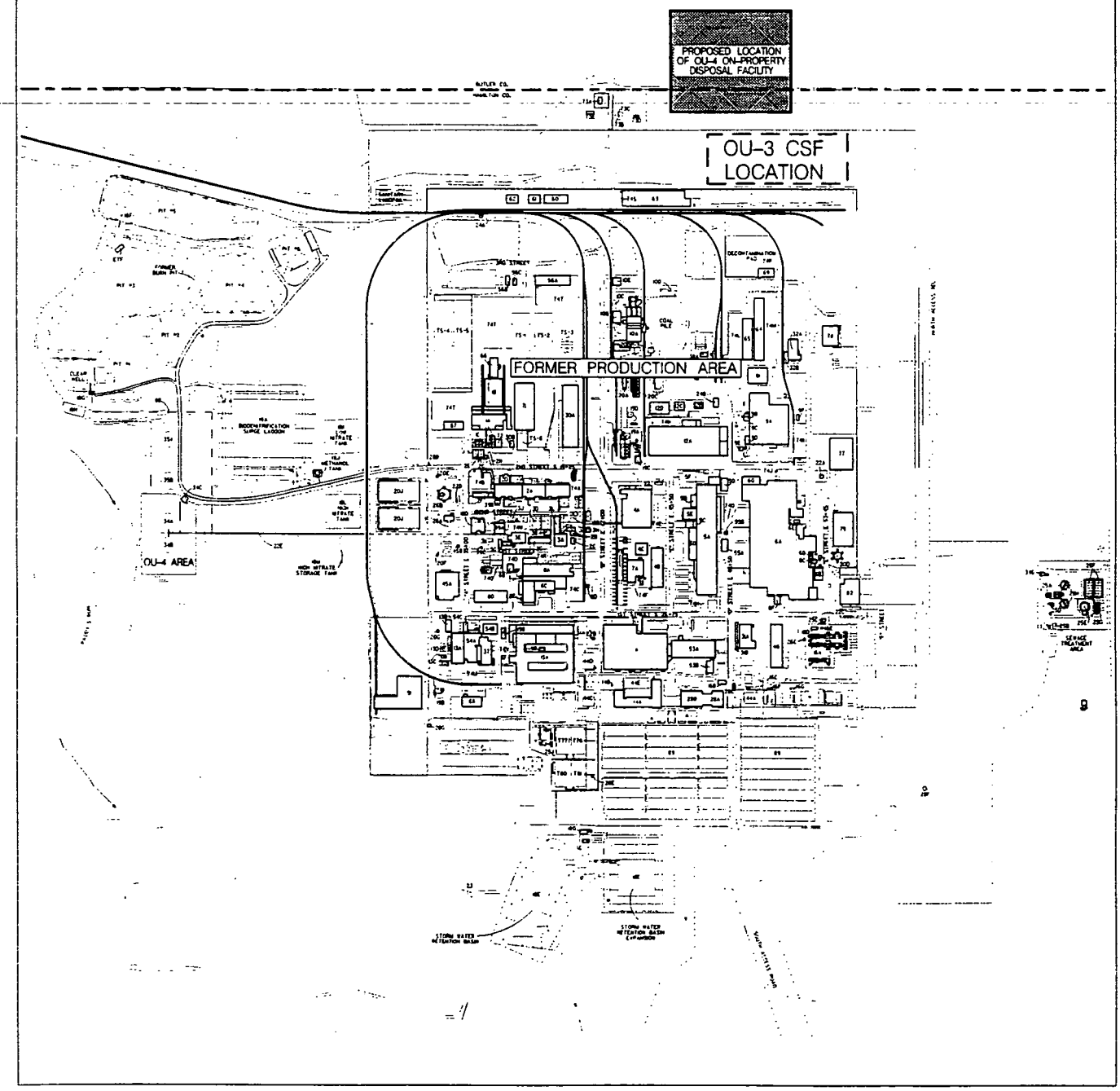
Under this alternative, the K-65 residues and cold metal oxides would be removed from Silos 1, 2, and 3 and treated in a newly constructed on-property vitrification facility. The sludges from the decant sump tank would also be removed and treated in the vitrification facility. Following treatment, the vitrified residues would be containerized and transported off site for disposal at the NTS.

Following removal of the residues, the concrete silo structures would be demolished. Additionally, the existing radon treatment system and other miscellaneous structures within the Operable Unit 4 area would be demolished. Further, following completion of treatment, the newly constructed vitrification facility would be disassembled. Surface scabbling, acid washing and other standard decontamination technologies would be applied to the extent practical to minimize the volume of waste requiring disposal. Opportunities for recycling of generated materials would also be explored.

Contaminated soils within the boundary of the Operable Unit 4 area would be excavated to the extent necessary to attain the proposed remediation levels previously defined in Table 5-2. To achieve these clean-up levels, a minimum six inches of soils would be removed from the entire Operable Unit 4 area. Excavated areas would be backfilled with clean fill and seeded.

Contaminated soil and debris would be placed into the central storage facility located in the northern portion of the site (Figure 6-3). This facility is being constructed pursuant to the approved work plan for Removal Action 17- (Improved Storage of Soil and Debris). The central storage facility would be maintained and monitored, as required.

FIGURE 6-3
PROPOSED LOCATION OF OPERABLE UNIT 4 ON-PROPERTY DISPOSAL FACILITY



SCALE

0 1600 FEET

<PROJECT*>-<8.5.11>-</res2227/fig6-2.dgn>-<OPER. UNIT 4>

The decision regarding the final disposition of the remaining Operable Unit 4 contaminated soil and debris would be placed in abeyance to take full advantage of planned and in progress waste minimization treatment processes. Further, this strategy enables the proper integration of disposal decisions on a sitewide basis. As planned treatment facilities become available under Operable Units 3 and 5 remedial actions, full consideration would be given to applying these systems to the inventoried contaminated materials from Operable Unit 4. Following the application of available waste minimization processes, the remaining Operable Unit 4 contaminated soil and debris would be disposed of consistent with the selected remedies for Operable Units 3 and 5.

The total estimated present worth cost for the preferred alternative is 95.4 million dollars. Table 6-3 summarizes the capital and operating and maintenance costs. The total estimated present worth cost is less than the sum of the total costs of the preferred alternatives for Subunit A, B, and C. This is due to the fact that Subunits A and B would share common costs associated with site preparation, construction of the silo contents removal work platform and processing facilities, and packaging and transportation. Further, the capital costs associated with construction of the on-property disposal facility have been removed.

On the basis of currently available information, the preferred alternative provides the best balance of trade-offs among the final alternatives with respect to the evaluation criteria. This alternative would achieve substantial risk reduction by removing the sources of contamination, treating the material for which exposures result in the highest risk, shipping the treated residues off site for disposal, and managing remaining contaminated soils and debris consistent with site-wide strategy. The proposed treatment alternative both reduces the mobility of the hazardous constituents and results in significant reduction in the volume of materials requiring disposal. DOE believes the preferred alternative would be protective of human health and the environment; comply with all regulatory requirements; be cost-effective; utilize permanent solutions to the maximum extent practical; and utilize treatment as a principal element of the response.

6.3.3 Summary of Preferred Alternative Impacts

As part of the comparative evaluation in Section 6.1, short-term and long-term environmental impacts were considered for each alternative. Section 4.0 and Appendix I of the Feasibility Study Report contain further details. The cumulative impacts of the preferred alternative for Operable Unit 4 are adequately represented by the discussions presented for the preferred alternative in each Subunit. Short-term environmental impacts associated with removal, vitrification, and transportation of treated Subunits A and B materials to the NTS will be minimized through engineered operations designed to control releases to the air, soil, surface water, and groundwater caused by remedial activities. No wetlands or floodplains will be impacted by short-term or long-term operations, either at the FEMP site or NTS. Long-term environmental impacts associated with the permanent disposal of Subunits A and B treated residues at NTS are minor. There may be minor short-term impacts to biota at the FEMP site during implementation of the preferred alternative. Long-term effects would be favorable

TABLE 6-3

SUMMARY OF COSTS
OPERABLE UNIT 4 PREFERRED ALTERNATIVE (Million $)

Capital Cost	93.6
Operating & Maintenance	
Short-Term	16.6
Long-Term	3.6
Present Worth Cost	95.4

Note:

- The accuracy of the cost estimates are between +50% and -30%.
- Estimates of Capital and Operating & Maintenance costs are expressed in terms of total costs. The total present worth cost is calculated from the toal cost figures applying a discount rate of 7% and an Operating & Maintenance period of 30 years.

to biota at the FEMP site due to cleanup actions; and no long-term impacts of biota are expected from disposal activities at NTS.

6.3.4 Ecological Risk Assessment

A qualitative evaluation has been conducted on residual contaminants of concern that will remain after completion of the Operable Unit 4 Remedial Action. The primary pathways of concern associated with ecological receptors coming in contact with Operable Unit 4 include surface soil (e.g., ingestion and plant uptake) and runoff of surface soil to surface water bodies (e.g., exposures to aquatic habitat and ingestion of surface water). The preferred alternative for Operable Unit 4 includes the removal of the surface soil from the entire Operable Unit 4 Study Area and the replacement of this soil with clean fill material, so ecological receptors will have very minimal contact with residual contaminants.

The pathways of concern associated with uranium in the subsoil is groundwater (e.g., ingestion of drinking water and normal contact). Refer to Appendix D of the Feasibility Study for Operable Unit 4 for more quantitative risk information related to human health. From an ecological risk standpoint, ecological receptors will have very minimal contact with the groundwater pathway. Therefore, residual contaminants (i.e., uranium) will not pose a risk to ecological receptors within Operable Unit 4 due to its limited availability to enter the surface soil and surface water pathway involving ecological receptors.

The Amended Consent Agreement between EPA and DOE stipulates that Operable Unit 5 is responsible for "Environmental Media" at the FEMP site, and therefore, is designated to prepare a Site-Wide Ecological Risk Assessment as part of the Remedial Investigation Report for Operable Unit 5. During a February 17, 1993, meeting at the FEMP site, an agreement was reached between Operable Unit 5 representatives and the chief representative of the EPA - Region V's Biological Technical Group, stating that the possible risks from current concentrations of site contaminants to ecological receptors inhabiting on-site and off-site areas not presently targeted for remediation must meet criteria to protect human health. Therefore, Operable Units 1 - 4 will not be evaluated in the Site-Wide Ecological Risk Assessment. Only those contaminants present in detectable quantities in the physical area of Operable Unit 5 and recorded in the RI/FS database will be evaluated in the Site-Wide Ecological Risk Assessment. However, it is the policy at the FEMP site to qualitatively address ecological risks related to residual contaminants of concern in the Feasibility Study reports for Operable Units 1 - 4.

7.0 COMMUNITY PARTICIPATION

Input from the public is an important element of the decision-making process for cleanup actions at the FEMP site. Comments on the proposed remedial action at the FEMP site will be received during a public review period following issuance of the Draft Feasibility Study/Proposed Plan-Environmental Impact Statement (FS/PP-EIS) for Operable Unit 4 documents. Oral comments may be presented at a public hearing that will be conducted. Written comments may be submitted at that public meeting or mailed to the following address before the close of the public comment period:

Mr. Ken Morgan	Mr. Jim Saric
Director, Public Information	U.S. Environmental Protection Agency
U.S. Department of Energy Fernald Field Office	77 West Jackson Boulevard
P.O. Box 398705	5HRE 8J
Cincinnati, OH 45239-8705	Chicago, IL 60604
513-648-3131	312-886-0992

Information concerning the schedule for the public hearing and dates for the comment period will be announced in the local medias and will be available from the Public Environmental Information center.

Information relevant to the proposed remedial actions, including the Remedial Investigation Report for Operable Unit 4, Baseline Risk Assessment, Feasibility Study Report, Proposed Plan, and supporting technical reports is in the Administrative Record. The Administrative Record is located at the Public Environmental Information Center, just south of the FEMP site. For information regarding the Public Environmental Information Center, call 513-738-0164.

PUBLIC ENVIRONMENTAL INFORMATION CENTER HOURS

10845 Hamilton-Cleves Highway
Harrison, OH 45030
Monday and Thursday, 9 a.m. to 8 p.m.
Tuesday, Wednesday and Friday, 9 a.m. to 4:30 p.m.
Saturday, 9 a.m. to 1 p.m.

GLOSSARY

Administrative Record: Documentation of Remedial Investigation/Feasibility Study activities for each operable unit. The documents in the Administrative Record are used to make decisions for the Fernald Environmental Management Project (FEMP) remediation program, as well as for short-term protective measures (removal actions) implemented until a final remediation plan can be put into effect. The Administrative Record is made available for public review so that community members have the opportunity to provide comments to the DOE on proposed cleanup activities at the FEMP site. The Administrative Record for the FEMP site is located at the Public Environmental Information Center (see below).

Amended Consent Agreement: The modified Consent Agreement signed in September, 1991, which includes the renegotiation framework and schedules for developing, implementing, and monitoring appropriate response actions at the Fernald Environmental Management Project (FEMP) and to facilitate cooperation, exchange of information, and participation of EPA and DOE in such actions.

Applicable or Relevant and Appropriate Requirements (ARARs): Any state or federal statute that pertains to protection of human life and the environment in addressing specific conditions or use of a particular cleanup technology at a National Priorities List (NPL) site.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA): A federal law, passed in 1980 and modified in 1986 (see SARA), that created a special tax to be placed in a trust fund. This trust fund, generally referred to as Superfund, is used to investigate and remedy abandoned or uncontrolled hazardous waste sites. Under this legislation, the US EPA can carry out one of two possible actions:

1. Pay for site remediation if those responsible for generating the waste cannot be located or are unwilling or unable to perform the work.

2. Use legal action to force those responsible for generating the waste to remediate the site or pay the government for the cost of remediation.

For the FEMP, the DOE is the responsible party, and is remediating the site with oversight from the US EPA in accordance with the Amended Consent Agreement.

Hazardous Waste: A discarded material of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity), or appears on special EPA lists.

Isotope: A variation of an element that has the same atomic number of protons but a different weight because of the number of neutrons. Various isotopes of the same element may have different radioactive behaviors, some are highly unstable.

National Environmental Protection Act of 1969 (NEPA): was signed into law in 1970. it declares a national environmental policy and promotes consideration of environmental concerns by federal agencies. Nonetheless, NEPA has had a pervasive effect on the federal decision-making process as a result of thousands of judicial decisions construing the statute's meaning in concrete situations.

National Priorities List (NPL): EPA's list of the most serious uncontrolled or abandoned hazardous waste sites identified for possible long-term remedial action under Superfund. A site must be on the NPL to receive money from the Trust Fund for remedial action. The list is based primarily on the score a site receives from the Hazard Ranking System. EPA is required to update the NPL at least once a year. The FEMP (formerly the Feed Materials Production Center) is on this list.

Nevada Test Site (NTS): A DOE owned facility that currently accepts low-level radioactive material from DOE facilities. This sparsely populated area is located 55 miles north of Las Vegas, Nevada in a dry climate.

Operable Unit: Term for each of a number of separate activities undertaken as part of a National Priorities List (NPL) site cleanup. A typical operable unit would be removing drums and tanks from the surface of a site. The FEMP has been divided into five operable units.

Picocurie (pCi): Measurement of radioactivity. A picocurie is a trillionth of a curie, representing about 2.2 radioactive particle disintegrations per minute. A curie is the basic unit used to describe the amount of radioactivity in a sample of material. It is based upon the approximate decay rate of 1 gram of radium which is 37 billion disintegrations of radioactive particles per second. Picocuries are often expressed in units related to a liquid volume unit such as picocuries per liter (pCi/L) or related to a solid volume unit such as picocuries per gram (pCi/g).

Public Environmental Information Center (PEIC): An information repository located approximately one and a half miles south of the FEMP site. In addition to the Administrative Record, the PEIC contains additional materials to help the public understand cleanup activities at the site, such as the Annual Environmental Report, news clippings, fact sheets and textbooks. For additional information about the PEIC, call (513) 738-0164 during normal operating hours (Refer to Section 7.0).

Rad: Unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs per gram or 0.01 joules per kilogram . Dose is the amount of energy deposited in body tissue due to radiation exposure.

Radionuclide: Radioactive element characterized according to its atomic mass and atomic number which can be man-made or naturally occurring. Radioisotopes can have a long life as soil or water pollutants, and are believed to have potentially mutagenic effects on the human body.

Radon: A colorless naturally occurring, radioactive, inert gaseous element formed by radioactive decay of radium atoms in soil or rocks.

Record of Decision: A public document that explains which cleanup alternative(s) will be used at National Priorities List sites under CERCLA.

Remedial Action: The actual construction or implementation phase of an National Priorities List (NPL) site cleanup that follows remedial design.

Remedial Investigation/Feasibility Study (RI/FS): Two distinct but closely related studies that are usually conducted at the same time. The Remedial Investigation/Feasibility Study is intended to:

1. Collect the data needed to determine the nature and extent of contamination at an NPL site;

2. Establish criteria for site remediation;

3. Identify and screen alternatives for remedial action;

4. Analyze the available technology and cost (e.g., feasibility) of each alternative.

At the FEMP, five Remedial Investigation/Feasibility Study documents will be prepared, one for each operable unit. Similar documents may also be prepared for a Comprehensive Site-Wide Operable Unit. The Remedial Investigation Report for Operable Unit 4 was first made available at the PEIC on April 19; the Feasibility Study Report for Operable Unit 4 will be available on September 10.

Removal Action: Short-term immediate actions taken to address releases of hazardous substances that require expedited response.

Resource Conservation and Recovery Act (RCRA): A federal law that established a regulatory system for tracking hazardous substances from the time they are generated until disposal. The law requires that safe and secure procedures be used to treat, transport, store and dispose of hazardous substances. RCRA is also designed to prevent the occurrence of new uncontrolled hazardous waste sites.

Superfund Amendments and Reauthorization Act (SARA): The 1986 law that reauthorized CERCLA. SARA Title III, a free-standing provision of the law, is of particular relevance to the FEMP site, since, among other functions, it provides for the establishment of the National Contingency Plan. This plan contains provisions for setting up the Administrative Record as a vehicle for public involvement in cleanup activities.

REFERENCES

American Cancer Society, 1992, "Cancer Facts and Figures-1992", Atlanta, Georgia.

Ebasco Environmental, 1993, "Wetlands Delineation Report of the FEMP, Draft," prepared by Fernald Environmental Management Project, Cincinnati, OH.

Environmental Laboratory, 1987, "Corps of Engineers Wetland Delineation Manual," Technical Report Y-87-1, U.S. Army Corps of Engineer Waterways Experiment Station, Vicksburg, MS.

Facemire, C. F., S. I. Guttman, D. R. Osborne, and R. H. Sperger, 1990, "Biological and Ecological Site Characterization of the Feed Materials Production Center," FMPC-SUB 018, prepared for Westinghouse Materials Co. of Ohio, Cincinnati, OH.

National Council on Radiation Protection and Measurements, 1991, "Effects of Ionizing Radiation on Aquatic Organisms," NCRP Report No. 109, NCRP, Bethesda, MD.

National Lead Company of Ohio, Inc. (NLO), 1953, (Memorandum from R. C. Heatherton, Subject: Leakage of K-65 Storage Tank No. 1).

Shanks, P. A. and R. A. Vogel, 1988, "The K-65 Waste Storage Silos at the Feed Materials Production Center," FMPC-2142, Westinghouse Materials Co. of Ohio.

U.S. Dept. of Agriculture, 1980 Soil Conservation Service, Ohio Dept. of Natural Resources, Division of Lands and Soil, and Ohio Agricultural Research and Development Center, 1980, "Soil Survey of Butler County, Ohio," USDA, ODNR, and Ohio Agricultural Research and Development Center, n.p.

U.S. Dept. of Agriculture, 1982 Soil Conservation Service, Ohio Dept. of Natural Resources, Division of Lands and Soil, and Ohio Agricultural Research and Development Center, 1982, "Soil Survey of Hamilton County, Ohio," USDA, ODNR, and Ohio Agricultural Research and Development Center, n.p.

U.S. Dept. of Energy, 1988, "Remedial Investigation and Feasibility Study, Feed Materials Production Center, Fernald, Ohio, Work Plan Revision 3," U.S. Dept of Energy, Oak Ridge Operations, Oak Ridge, TN.

U.S. Dept. of Energy, 1989, "A Probabilistic Risk Assessment for the K-65 Silos at the FMPC," University of Cincinnati, FMPC/SUB-029 UC-702.

U.S. Dept. of Energy, 1990, "Engineering Evaluation/Cost Analysis (EE/CA) K-65 Residue Removal Action at the Feed Materials Production Center, Fernald, Ohio," prepared by Bechtel National, Inc.

U.S. Dept. of Energy, 1991, Nevada Test Site Annual Site Environmental Report-1990, DOE/NV 10630-20, Nevada Field Office, Las Vegas, NV.

U.S. Dept. of Energy, 1992, "Risk Assessment Work Plan Addendum," Final Draft, FEMP, Remedial Investigation and Feasibility Study, DOE, Fernald Field Office, Fernald, OH.

U.S. Dept. of Energy, 1993a, "Remedial Investigation Report for Operable Unit 4," DOE, Fernald Field Office, August 1993.

U.S. Dept. of Energy, 1993b, Site-Wide Characterization Report FEMP, Fernald, OH, Remedial Investigation and Feasibility Study, Draft, DOE, Fernald Field Office, Fernald, OH, March 1993.

U.S. Dept. of Energy, 1993c, "Cement Stabilization/Chemical Extraction Treatability Study Report for Operable Unit 4," DOE, Fernald Field Office, Fernald, OH.

U.S. Dept. of Energy, 1993d, "Operable Unit 4 Treatability Study Report for the Vitrification of Residues from Silos 1, 2, and 3," DOE, Fernald Field Office, Fernald, OH.

U.S. Environmental Protection Agency, 1988a, "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA," EPA/540/G-89/004, EPA, Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency, 1988b, "Federal Guidance Report No. 11."

U.S. Environmental Protection Agency, 1989a, "Environmental Protection Agency National Primary Drinking Water Regulations," 40 CFR 141, as amended by 54FR27526,27562, June 29, 1989 and 54FR30001, July 17, 1989, The Bureau of National Affairs, Inc., Washington, DC.

U.S. Environmental Protection Agency, 1989b, Guide to Treatment Technologies for Hazardous Wastes at Superfund Sites.

U.S. Environmental Protection Agency, 1989c, "Guidance on Preparing Superfund Decision Documents: The Proposed Plan, The Record of Decision, Explanation of Significant Differences, The Record of Decision Amendment," EPA/540/G-89/007, EPA, Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency, 1989d, "National Emissions Standards for Hazardous Air Pollutants; Radionuclides, Final Rule and Notice of Reconsideration (40 CFR Part 61)", Federal Register, 54(240):51654-51715, December 15.

U.S. Environmental Protection Agency, 1990, "National Oil and Hazardous Substances Pollution Contingency Plan; Final Rule (40 CFR Part 300)," Federal Register, 55(46):8666-8865, March 8, 1990.

U.S. Environmental Protection Agency, 1991a "Risk Assessment Guidance For Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk - based Preliminary Remediation (goals)," OSWER directive 9285.7-01B.

U.S. Environmental Protection Agency, 1991b, "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions," memo from D. R. Clay, Office of Solid Waste and Emergency Response, Directive 9355.0-30, April 22, 1991.

U.S. Environmental Protection Agency, 1992a Integrated Risk Information System (IRIS), on-line data service. EPA, Washington, DC.

U.S. Environmental Protection Agency, 1992b Health Effects Assessment Summary Tables, Annual Update FY 1992, including Supplement A, July 1992, OERR 9200.6-303 (92-1)

U.S. Geological Survey, 1981, Shandon, Ohio, Quadrangle Map, Reston, VA.

U.S. Nuclear Regulatory Commission (NRC), no date, Regulatory Guide 1.86, "Residual Radioactive Material as Surface Contamination."

PROPOSED PLAN/OTHER DOCUMENT CROSS REFERENCE MATRIX

Proposed Plan Section	Other FEMP Document *
2.1 Site History	RI Section 1.1
2.2 Site Description	RI Section 1.1
3.1 The Operable Unit Concept	FS Appendix K, Section K.1.4
3.2 Scope and Role of Operable Unit 4	FS Section 1.0
4.1 Overview of the Baseline Risk Assessment	RI Appendix D FS Section 1.6
4.2 Ecological Impacts	FS Appendix I
5.1 No-Action Alternative for All Subunits	FS Section 4.2
5.2 Subunit A - Silo 1 and 2 Contents	FS Section 4.2
5.3 Subunit B - Silo Contents	FS Section 4.3
5.4 Subunit C - Silos 1, 2, 3, and 4 Structures, Soils and Debris	FS Section 4.4
6.1 Evaluation Criteria	FS Section 4.1.2
6.2 Summary of the Comparative Analysis of Alternatives	FS Section 5.2
6.3 Preferred Alternative	FS Section 5.6
6.4 Summary of Preferred Alternative Impacts	FS Appendix I

* FS refers to the Operable Unit 4 Feasibility Study Report
RI refers to the Operable Unit 4 Remedial Investigation Report

☆ U.S. GOVERNMENT PRINTING OFFICE: 1993-750-276/80013