U-006-402.3

1804

INITIAL SCREENING OF ALTERNATIVES FOR OPERABLE UNIT 4 TASK 12 REPORT AUGUST 1990

8-3-90

DOE/EPA
15
REPORT

[redacted]

1804

INITIAL SCREENING OF ALTERNATIVES FOR OPERABLE UNIT 4

TASK 12 REPORT

FEED MATERIALS PRODUCTION CENTER
FERNALD, OHIO

REMEDIAL INVESTIGATION and FEASIBILTY STUDY

August 1990

U.S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE

DRAFT

1804

DRAFT

DETAILED ANALYSIS OF ALTERNATIVES FOR OPERABLE UNIT 4

TASK 12 REPORT

FEED MATERIALS PRODUCTION CENTER
FERNALD, OHIO

REMEDIAL INVESTIGATION and FEASIBILITY STUDY

DRAFT

Prepared for

U.S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE

Prepared by

ADVANCED SCIENCES, INC.
IT CORPORATION

August 1990
FMPC-0412-5

2

TABLE OF CONTENTS

	PAGE
List of Tables	xi
List of Figures	xii
List of Acronyms	xiii
Distribution List	xv
Executive Summary	ES-1
1.0 Introduction	1-1
1.1 Purpose	1-1
1.2 Organization of Report	1-1
1.3 Background	1-2
1.3.1 Site Description	1-2
1.3.2 Operable Unit Description	1-2
1.3.3 Nature and Extent of Contamination	1-6
2.0 Technology and Process Option Refinement	2-1
2.1 Environmental Isolation Enclosure	2-1
2.2 Mechanical, Hydraulic, Pneumatic Removal	2-5
2.2.1 Mechanical Removal	2-5
2.2.2 Hydraulic Removal	2-5
2.2.3 Pneumatic Removal	2-7
2.3 Silo Demolition	2-7
2.4 Stabilization/Vitrification	2-9
2.4.1 Stabilization	2-9
2.4.2 Vitrification	2-10
2.5 Air Treatment Process	2-11
2.6 Water Treatment - Metals Removal, Ion Exchange, and Denitrification	2-12
2.7 Impermeable Cap	2-13
2.8 On-Site Disposal Facility	2-15
2.9 Packaging/Transportation	2-15
2.9.1 Limited Quantities	2-21
2.9.2 LSA	2-21
2.9.3 Type A	2-22
2.9.4 Type B	2-23
3.0 Development of Alternatives	3-1
3.1 Summary	3-1

DRAFT

TABLE OF CONTENTS
(Continued)

		PAGE
3.1.1	Remedial Action Objectives	3-1
3.1.2	General Response Actions	3-2
3.1.3	Current Status	3-2
3.2	Summary of Alternatives	3-3
3.2.1	Alternative 0 - No Action	3-3
3.2.2	Alternative 1 - Nonremoval, Silo Isolation - Silos 1, 2, 3	3-3
3.2.3	Alternative 2 - Nonremoval In Situ Stabilization and Cap - Silos 1, 2, 3	3-3
3.2.4	Alternative 3 - Removal, and On-Site Disposal - Silo 3	3-5
3.2.5	Alternative 4 - Removal of Metal Oxides and Off-Site Disposal - Silo 3	3-5
3.2.6	Alternative 5 - Removal and Replacement in Rehabilitated Silo - Silo 3	3-5
3.2.7	Alternative 6 - Removal, Treatment, and On-Site Disposal - K-65 Silos	3-5
3.2.8	Alternative 7 - Removal, Treatment, and Off-Site Disposal - K-65 Silos	3-5
3.2.9	Alternative 8 - Removal, Contaminant Separation, and On-Site Disposal - K-65 Silos	3-5
3.2.10	Alternative 9 - Removal, Contaminant Separation, and Off-Site Disposal - K-65 Silos	3-5
4.0	Alternative Screening Methodology	4-1
4.1	Introduction	4-1
4.2	Refinement of Alternatives	4-1
4.3	Alternative Evaluation Process	4-2
4.3.1	Effectiveness Evaluation	4-4
4.3.2	Implementability and Reliability Evaluation	4-4
4.3.3	Cost Evaluation	4-5
4.3.4	Innovative Technologies	4-5
4.4	Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)	4-5
4.5	Waste Disposal Considerations	4-6
4.5.1	Long-Term Effectiveness	4-6
4.5.2	Short-Term Effectiveness	4-7
4.5.3	Reduction in Toxicity, Mobility, and Volume through Treatment	4-7

TABLE OF CONTENTS
(Continued)

	PAGE
4.5.4 Implementability	4-7
4.5.5 Cost	4-7
4.5.6 Overall Protection of Human Health and the Environment	4-8
4.5.7 Land Disposal Restrictions	4-8
5.0 Screening of Alternatives	5-1
5.1 Alternative 0 - No Action	5-1
5.1.1 Description	5-1
5.1.1.1 System Requirements	5-1
5.1.1.2 Size and Configuration	5-1
5.1.1.3 Remediation Time Frame	5-1
5.1.1.4 Spatial Requirements	5-2
5.1.1.5 Packaging Requirements	5-2
5.1.1.6 Waste Generated	5-2
5.1.1.7 Permits Required	5-2
5.1.2 Effectiveness	5-2
5.1.2.1 Protection of Human Health	5-2
5.1.2.2 Protection of the Environment	5-2
5.1.2.3 Reduction in Toxicity, Mobility, and Volume through Treatment	5-2
5.1.3 Implementability	5-2
5.1.3.1 Constructability	5-2
5.1.3.2 Reliability	5-3
5.1.3.3 Maintenance/Operation	5-3
5.1.3.4 Agency Approvals	5-3
5.1.3.5 Special Engineering and Equipment	5-3
5.1.4 Cost	5-3
5.1.5 Additional Data Needs	5-3
5.1.6 Screening Summary	5-3
5.2 Alternative 1 - Nonremoval, Silo Isolation - Silos 1, 2, 3	5-4
5.2.1 Description	5-4
5.2.1.1 System Requirements	5-4
5.2.1.2 Size and Configuration	5-4

DRAFT

TABLE OF CONTENTS
(Continued)

		PAGE
5.2.1.3	Remediation Time Frame	5-5
5.2.1.4	Spatial Requirements	5-5
5.2.1.5	Packaging Requirements	5-5
5.2.1.6	Waste Generated	5-5
5.2.1.7	Permits Required	5-5
5.2.2	Effectiveness	5-5
5.2.2.1	Protection of Human Health	5-5
5.2.2.2	Protection of the Environment	5-6
5.2.2.3	Reduction in Toxicity, Mobility, and Volume through Treatment	5-6
5.2.3	Implementability	5-6
5.2.3.1	Constructability	5-6
5.2.3.2	Reliability	5-6
5.2.3.3	Maintenance/Operation	5-6
5.2.3.4	Agency Approvals	5-6
5.2.3.5	Special Engineering and Equipment	5-6
5.2.4	Cost	5-6
5.2.5	Additional Data Needs	5-7
5.2.6	Screening Summary	5-7
5.3	Alternative 2 - Nonremoval, In Situ Stabilization and Cap - Silos 1,2,3	5-7
5.3.1	Description	5-7
5.3.1.1	System Requirements	5-8
5.3.1.2	Size and Configuration	5-8
5.3.1.3	Remediation Time Frame	5-8
5.3.1.4	Spatial Requirements	5-8
5.3.1.5	Packaging Requirements	5-8
5.3.1.6	Waste Generated	5-8
5.3.1.7	Permits Required	5-9
5.3.2	Effectiveness	5-9
5.3.2.1	Protection of Human Health	5-9
5.3.2.2	Protection of the Environment	5-9

TABLE OF CONTENTS
(Continued)

		PAGE
5.3.2.3	Reduction in Toxicity, Mobility, and Volume through Treatment	5-9
5.3.3	Implementability	5-10
5.3.3.1	Constructability	5-10
5.3.3.2	Reliability	5-10
5.3.3.3	Maintenance/Operation	5-10
5.3.3.4	Agency Approvals	5-10
5.3.3.5	Special Engineering and Equipment	5-10
5.3.4	Cost	5-10
5.3.5	Additional Data Needs	5-11
5.3.6	Screening Summary	5-11
5.4	Alternative 3 - Removal and On-Site Disposal - Silo 3	5-11
5.4.1	Description	5-11
5.4.1.1	System Requirements	5-13
5.4.1.2	Size and Configuration	5-13
5.4.1.3	Remediation Time Frame	5-13
5.4.1.4	Spatial Requirements	5-13
5.4.1.5	Packaging Requirements	5-13
5.4.1.6	Waste Generated	5-14
5.4.1.7	Permits Required	5-14
5.4.2	Effectiveness	5-14
5.4.2.1	Protection of Human Health	5-14
5.4.2.2	Protection of the Environment	5-14
5.4.2.3	Reduction in Toxicity, Mobility, and Volume through Treatment	5-14
5.4.3	Implementability	5-14
5.4.3.1	Constructability	5-14
5.4.3.2	Reliability	5-15
5.4.3.3	Maintenance/Operation	5-15
5.4.3.4	Agency Approvals	5-15
5.4.3.5	Special Engineering and Equipment	5-15
5.4.4	Cost	5-15
5.4.5	Additional Data Needs	5-15

TABLE OF CONTENTS
(Continued)

		PAGE
5.4.6	Screening Summary	5-15
5.5	Alternative 4 - Removal and Off-Site Disposal - Silo 3	5-15
5.5.1	Description	5-15
5.5.1.1	System Requirements	5-16
5.5.1.2	Size and Configuration	5-16
5.5.1.3	Remediation Time Frame	5-16
5.5.1.4	Spatial Requirements	5-16
5.5.1.5	Packaging/Transportation Requirements	5-16
5.5.1.6	Waste Generated	5-18
5.5.1.7	Permits Required	5-18
5.5.2	Effectiveness	5-18
5.5.2.1	Protection of Human Health	5-18
5.5.2.2	Protection of the Environment	5-19
5.5.2.3	Reduction in Toxicity, Mobility, and Volume through Treatment	5-19
5.5.3	Implementability	5-19
5.5.3.1	Constructability	5-19
5.5.3.2	Reliability	5-19
5.5.3.3	Maintenance/Operation	5-19
5.5.3.4	Agency Approvals	5-19
5.5.3.5	Special Engineering and Equipment	5-20
5.5.4	Cost	5-20
5.5.5	Additional Data Needs	5-20
5.5.6	Screening Summary	5-20
5.6	Alternative 5 - Removal and Replacement in Rehabilitated Silo - Silo 3	5-20
5.6.1	Description	5-20
5.6.1.1	System Requirements	5-21
5.6.1.2	Size and Configuration	5-21
5.6.1.3	Remediation Time Frame	5-21
5.6.1.4	Spatial Requirements	5-21
5.6.1.5	Packaging Requirements	5-21

DRAFT

TABLE OF CONTENTS
(Continued)

		PAGE
5.6.1.6	Waste Generated	5-21
5.6.1.7	Permits Required	5-21
5.6.2	Effectiveness	5-22
5.6.2.1	Protection of Human Health	5-22
5.6.2.2	Protection of the Environment	5-22
5.6.2.3	Reduction in Toxicity, Mobility, and Volume through Treatment	5-22
5.6.3	Implementability	5-22
5.6.3.1	Constructability	5-22
5.6.3.2	Reliability	5-23
5.6.3.3	Maintenance/Operation	5-23
5.6.3.4	Agency Approvals	5-23
5.6.3.5	Special Engineering and Equipment	5-23
5.6.4	Cost	5-23
5.6.5	Additional Data Needs	5-23
5.6.6	Screening Summary	5-23
5.7	Alternative 6 - Removal, Treatment, and On-Site Disposal - K-65 Silos	5-24
5.7.1	Description	5-24
5.7.1.1	System Requirements	5-24
5.7.1.2	Size and Configuration	5-24
5.7.1.3	Remediation Time Frame	5-26
5.7.1.4	Spatial Requirements	5-26
5.7.1.5	Packaging Requirements	5-26
5.7.1.6	Waste Generated	5-26
5.7.1.7	Permits Required	5-26
5.7.2	Effectiveness	5-27
5.7.2.1	Protection of Human Health	5-27
5.7.2.2	Protection of the Environment	5-27
5.7.2.3	Reduction in Toxicity, Mobility, and Volume through Treatment	5-27
5.7.3	Implementability	5-27
5.7.3.1	Constructability	5-27

TABLE OF CONTENTS
(Continued)

		PAGE
5.7.3.2	Reliability	5-27
5.7.3.3	Maintenance/Operation	5-28
5.7.3.4	Agency Approvals	5-28
5.7.3.5	Special Engineering and Equipment	5-28
5.7.4	Cost	5-28
5.7.5	Additional Data Needs	5-28
5.7.6	Screening Summary	5-28
5.8	Alternative 7 - Removal, Treatment, and Off-Site Disposal	5-29
5.8.1	Description	5-29
5.8.1.1	System Requirements	5-29
5.8.1.2	Size and Configuration	5-29
5.8.1.3	Remediation Time Frame	5-29
5.8.1.4	Spatial Requirements	5-31
5.8.1.5	Packaging/Transportation Requirements	5-31
5.8.1.6	Waste Generated	5-31
5.8.1.7	Permits Required	5-31
5.8.2	Effectiveness	5-32
5.8.2.1	Protection of Human Health	5-32
5.8.2.2	Protection of the Environment	5-32
5.8.2.3	Reduction in Toxicity, Mobility, and Volume through Treatment	5-32
5.8.3	Implementability	5-32
5.8.3.1	Constructability	5-32
5.8.3.2	Reliability	5-32
5.8.3.3	Maintenance/Operation	5-33
5.8.3.4	Agency Approvals	5-33
5.8.3.5	Special Engineering and Equipment	5-33
5.8.4	Cost	5-33
5.8.5	Additional Data Needs	5-33
5.8.6	Screening Summary	5-33
5.9	Alternative 8 - Removal, Contaminant Separation, and On-Site Disposal - K-65 Silos	5-33
5.9.1	Description	5-33

DRAFT

TABLE OF CONTENTS
(Continued)

		PAGE
5.9.1.1	System Requirements	5-36
5.9.1.2	Size and Configuration	5-36
5.9.1.3	Remediation Time Frame	5-36
5.9.1.4	Spatial Requirements	5-36
5.9.1.5	Packaging Requirements	5-37
5.9.1.6	Waste Generated	5-37
5.9.1.7	Permits Required	5-37
5.9.2	Effectiveness	5-37
5.9.2.1	Protection of Human Health	5-37
5.9.2.2	Protection of the Environment	5-37
5.9.2.3	Reduction in Toxicity, Mobility, and Volume through Treatment	5-38
5.9.3	Implementability	5-38
5.9.3.1	Constructability	5-38
5.9.3.2	Reliability	5-38
5.9.3.3	Maintenance/Operation	5-38
5.9.3.4	Agency Approvals	5-38
5.9.3.5	Special Engineering and Equipment	5-38
5.9.4	Cost	5-38
5.9.5	Additional Data Needs	5-39
5.9.6	Screening Summary	5-39
5.10	Alternative 9 - Removal, Contaminant Separation, and Off-Site Disposal - K-65 Silos	5-39
5.10.1	Description	5-39
5.10.1.1	System Requirements	5-39
5.10.1.2	Size and Configuration	5-39
5.10.1.3	Remediation Time Frame	5-41
5.10.1.4	Spatial Requirements	5-41
5.10.1.5	Packaging/Transportation Requirements	5-41
5.10.1.6	Waste Generated	5-42
5.10.1.7	Permits Required	5-42
5.10.2	Effectiveness	5-42
5.10.2.1	Protection of Human Health	5-42

TABLE OF CONTENTS
(Continued)

	PAGE
5.10.2.2 Protection of the Environment	5-42
5.10.2.3 Reduction in Toxicity, Mobility, and Volume through Treatment	5-42
5.10.3 Implementability	5-43
5.10.3.1 Constructability	5-43
5.10.3.2 Reliability	5-43
5.10.3.3 Maintenance/Operation	5-43
5.10.3.4 Agency Approvals	5-43
5.10.3.5 Special Engineering and Equipment	5-43
5.10.4 Cost	5-43
5.10.5 Additional Data Needs	5-43
5.10.6 Screening Summary	5-44
6.0 General Summary	6-1
6.1 Alternatives Recommended for Detailed Analysis	6-1
6.2 Additional Data Needs	6-4
6.2.1 Sampling/Studies	6-4
6.2.2 ARARs	6-4
6.3 Detailed Analysis Preview	6-4

References

Appendices

A. ARARs

B. Silo Analytical Data

DRAFT

LIST OF TABLES

TABLE NO.	TITLE	PAGE
ES-1	Alternative Evaluation Matrix	ES-5
1-1	Silo Waste Characteristics	1-9
1-2	Radionuclide Concentration Summary in the Silo Waste	1-10
1-3	Chemical Concentrations in the Silos	1-11
3-1	Remedial Action Alternatives	3-4
6-1	Alternative Evaluation Matrix	6-2
6-2	Cost Estimate for Remedial Action Alternatives	6-3

DRAFT

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1-1	5 Mile Radius Map, Feed Materials Production Center	1-3
1-2	Major Features of the Feed Materials Production Center	1-4
1-3	Waste Storage Area	1-5
1-4	Typical Cross-Section through Silos 1 and 2	1-7
1-5	Cross-Section through Silo 3	1-8
2-1	Conceptual View of Environmental Isolation Enclosure (EIE) Over K-65 Silos	2-2
2-2	Plan View of EIE and Berm Modification	2-3
2-3	Sectional View of EIE, Section A-A	2-4
2-4	Hydraulic Removal of Silo Material	2-6
2-5	Vacuum Removal of Silo Material	2-8
2-6	Water Treatment - Metals Removal, Ion-Exchange and Denitrification	2-14
2-7	Capping Profile	2-16
2-8	Tumulus-Structural Slab	2-17
2-9	Tumulus-Compacted Coarse Sand Base	2-18
2-10	Greater Confinement Disposal Vault Facility (GCD)	2-19
2-11	GCD with Structural Slab and Vault Placed Above Grade	2-20
4-1	Relationship of Screening Criteria to the Nine Evaluation Criteria	4-3
5-1	Alternative 3 - Removal and On-Site Disposal - Silo 3	5-12
5-2	Alternative 4 - Removal and Off-Site Disposal - Silo 3	5-17
5-3	Alternative 6 - Removal, Treatment, On-Site Disposal - Silos 1, 2	5-26
5-4	Alternative 7 - Removal, Treatment, Off-Site Disposal - Silos 1, 2	5-30
5-5	Alternative 8 - Removal, Contaminant Separation, On-Site Disposal - Silos 1, 2	5-35
5-6	Alternative 9 - Removal, Contaminant Separation, Off-Site Disposal - Silos 1, 2	5-40

LIST OF ACRONYMS

APC	Air Pollution Control
ARARs	Applicable or relevant and appropriate requirements
AWQC	Ambient water quality criteria
BDAT	Best demonstrated available treatment
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COE	U.S. Army Corps of Engineers
CWA	Clean Water Act
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EIE	Environmental isolation enclosure
EPA	U.S. Environmental Protection Agency
FFCA	Federal Facilities Compliance Agreement
FMPC	Feed Materials Production Center
FS	Feasibility study
GCD	Greater confinement disposal
HEPA	High efficiency particulate absolute
HIC	High integrity containers
HVAC	Heating, ventilation, and air conditioning
ISV	In situ vitrification
LCDS	Leachate collection and detection system
LDR	Land disposal restrictions
LSA	Low specific activity
MCL	Maximum contaminant level
MCLG	Maximum contaminant level goal
MPRSA	Marine Protection Research and Sanctuaries Act
NAAQS	National ambient air quality standards
NCP	National Contingency Plan
NESHAP	National Emission Standards for Hazardous Air Pollutants
NLO	National Lead (Company) of Ohio
NPDES	National pollutant discharge elimination system
NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site

LIST OF ACRONYMS

OAC	Ohio Administrative Code
O&M	Operation and maintenance
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
ORC	Ohio Revised Code
OSWER	Office of Solid Waste and Emergency Response
OU4	Operable Unit 4
RI	Remedial investigation
RI/FS	Remedial investigation/feasibility study
SARA	Superfund Amendments and Reauthorization Act of 1986
SCO	Surface contaminated object
SDWA	Safe Drinking Water Act
SWDA	Solid Waste Disposal Act
TBC	To be considered
TCLP	Toxicity characteristic leaching procedure
TSCA	Toxic Substances Control Act
UIC	Underground injection control
WMCO	Westinghouse Materials Company of Ohio

DRAFT

DISTRIBUTION LIST

Project Director - John Wood, Fernald
Project Technical Manager - John Razor, Fernald
Technical Manager - Bob Galbraith, Fernald
Operable Unit/Task Managers - Dave Harmer, Knoxville
Robin Smith, Pittsburgh
Sam Wolinsky, Fernald
Dan Smith, Oak Ridge
Project QA Officer - Larry Sexton, Fernald
Technical QA Officer - Don Mack, Knoxville
Site Project Files - Fernald
IT-Monroeville Project Central Files
IT-Knoxville Project Central Files
ASI-Oak Ridge Project Files

DOE COR - Bobby Davis, Fernald
WMCO - Pat Hopper, Fernald
Lee Wan & Associates - M. Neal, Fernald

DOE-HQ - Randi Allen, Washington, DC
Carolyn Osborne
Lisa Feldt

EPA, Region 5 - Catherine McCord, Chicago
OEPA - Graham Mitchell, Dayton

DRAFT

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

This document presents the Initial Screening of Alternatives for Operable Unit 4 at the Feed Materials Production Center (FMPC), Fernald, Ohio, which was conducted as part of the site-wide Remedial Investigation/Feasibility Study (RI/FS) pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Operable Unit 4 includes the waste storage silos (two K-65 silos and the Silo 3) and the potentially contaminated soils surrounding them.

REMEDIAL ACTION OBJECTIVES

At the time of the activities of Task 12, the remedial action objectives came directly from the RI/FS Work Plan, Revision 3, March 31, 1988. The objectives directly applicable to Operable Unit 4 were to:

- Control and reduce the release of radon gas from waste
- Control the migration of contaminants to environmental media that would exceed public health or environmental standards
- Control direct contact with contaminated structures
- Correct structural conditions that could lead to the sudden release of chemicals or radionuclides.

The remedial action objectives were formulated to protect human health and the environment by isolating, removing, or treating the source of contamination. During Task 12, they were kept general and did not quantify the acceptable levels for the contaminants of concern for all pathways and receptors as they were not action levels or goals.

The previous task in the RI/FS for Operable Unit 4 screened remedial action technologies, developed process options and identified viable remedial action alternatives based on those process options. A brief description of each remedial action alternative is provided in the following paragraphs.

SUMMARY OF ALTERNATIVES

In addition to the no-action alternative, nine distinct remedial action alternatives have been developed for Operable Unit 4. One reason for the relatively large number of alternatives is the significant differences in the material properties of the K-65 silos (Silos 1 and 2) and the metal

oxide silo (Silo 3). There are two waste nonremoval and four waste removal alternatives for the K-65 silos, and there are three waste nonremoval and two waste removal alternatives for Silo 3.

Alternative 0 - No Action

The no-action alternative provides no remediation and simply leaves the silos and silo wastes in their present state. The installation of monitoring equipment and silo maintenance would cost up to $1 million.

Alternative 1 - Nonremoval, Silo Isolation - K-65 Silos and Silo 3

This nonremoval alternative for both the K-65 silos and Silo 3 consists of enhancing the containment integrity of the silos and utilizing them as permanent disposal facilities. An impermeable clay cap and slurry walls are two of the technologies considered for this alternative.

The cost estimate for Alternative 1 is $13 million.

Alternative 2 - Nonremoval, In Situ Stabilization and Cap - K-65 Silos and Silo 3

This nonremoval alternative for all silos consists of in situ stabilization and capping. Both conventional physical stabilization technologies (solidification, encapsulation, etc.) and vitrification are considered options. The capping and isolation technologies, with the exception of the slurry wall, are identical to those described in Alternative 1.

The cost estimate for Alternative 2 is $19 million if the waste is solidified or $24 million if the waste is vitrified.

Alternative 3 - Removal and On-Site Disposal - Silo 3

This removal alternative for Silo 3 calls for mechanical, hydraulic, or pneumatic waste removal with disposal in an engineered on-site disposal facility without interim treatment or stabilization. This includes silo demolition and disposal of the debris.

The cost estimate for Alternative 3 is $49 million.

Alternative 4 - Removal of Metal Oxides and Off-Site Disposal - Silo 3

This alternative for Silo 3 is identical to Alternative 3 with the exception that the waste is packaged for shipment to an approved off-site disposal facility.

The cost estimate for Alternative 4 is $9 million if the waste is transported as low specific activity (LSA) material or $25 million if the waste is transported as Type B material.

Alternative 5 - Removal and Replacement in Rehabilitated Silo - Silo 3

This alternative for Silo 3 provides for the removal of the metal oxides to a rehabilitated Silo 3 or Silo 4 reconstructed as a permanent disposal facility.

A cost estimate for Alternative 5 was not fully developed because inadequate effectiveness and implementability caused the alternative to be dropped.

Alternative 6 - Removal, Treatment, and On-Site Disposal - K-65 Silos

This removal alternative for the K-65 silos calls for the removal and conventional stabilization or vitrification of the waste prior to on-site disposal in an engineered disposal facility. This includes silo demolition and disposal of the debris.

The cost estimate for Alternative 6 is $65 million.

Alternative 7 - Removal, Treatment, and Off-Site Disposal - K-65 Silos

This alternative for removal of the K-65 waste is identical to Alternative 6 with the exception that the waste is packaged for shipment to an approved off-site disposal facility.

The cost estimate for Alternative 7 is $37 million if the waste is shipped as LSA material or $42 million if the waste is shipped as Type B material.

Alternative 8 - Removal, Contaminant Separation, and On-Site Disposal - K-65 Silos

This removal alternative for the K-65 waste is similar to Alternative 6 but adds an additional step of contaminant separation to remove various radionuclides and metals before stabilization and on-site disposal. This results in significant volume reduction and allows for the possible recovery of precious metals. This includes silo demolition and disposal of the debris.

The cost estimate for Alternative 8 is $58 million.

Alternative 9 - Removal, Contaminant Separation, and Off-Site Disposal - K-65 Silos

This alternative is identical to Alternative 8, with the exception that the waste would be packaged and shipped to an approved off-site disposal facility.

The cost estimate for Alternative 9 is $27 million with waste being shipped as Type B material. The specific radioactivity of the separated and concentrated contaminants is too high for LSA shipment.

SCREENING OF ALTERNATIVES

In order to reduce the number of alternatives subjected to the eventual detailed analysis phase, the alternatives were screened according to their performance in the areas of effectiveness, implementability, and cost. These screening criteria are outlined in OSWER Directive 9355.3-1, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. The first activity in the selection process was to describe each alternative in the following terms:

- System requirements
- Size and configuration
- Remediation time frame
- Spatial requirements
- Packaging requirements
- Wastes generated
- Permits required

The short- and long-term effectiveness evaluations were determined by these considerations:

- Protection of human health
- Protection of the environment
- Reduction in toxicity, mobility, and volume through treatment

Evaluation of implementability determined the technical and administrative feasibility under these criteria:

- Constructability
- Reliability
- Maintenance/Operation
- Agency approvals
- Special engineering and equipment

The cost estimate range (as defined in OSWER Directive 9355.3.-01, page 4-24) were estimated and have been presented above with the descriptions of the alternatives. Operation and maintenance costs, however, constitute a small portion of this early estimate and were considered qualitatively as part of the implementability, but not shown as separate items.

The nine alternatives were given numerical rankings under each of the above criteria. The criteria were applied equally to all the alternatives; that is, they were not weighted. It was found that all except one of the alternatives had numerical scores that fell within a fairly narrow range. Alternative 5 was clearly ranked lower than the others. It failed to offer any advantages not provided by other alternatives. Therefore, Alternative 5 will not be carried into further detailed development. Table ES-1 Alternative Evaluation Matrix presents the numerical scoring.

A major factor in the inability to distinguish between the other alternatives is the limited information currently available. Characterization of the materials in Operable Unit 4 is not complete and treatability studies have not been started. The alternatives, therefore, must be carried into the subsequent detailed analysis of alternatives, where they will be evaluated and screened in light of available information.

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

Applicable or relevant and appropriate requirements (ARARs) are to be progressively developed and applied on a site-specific basis as the RI/FS proceeds. The initial step in the process entailed the listing of all potential ARARs for the FMPC site. The comprehensive listing was completed as part of the RI/FS Work Plan. These potential ARARs were categorized as chemical-specific, location-specific, and action-specific. Since ARARs do not cover every circumstance, it may also be necessary to consult other reliable information. To this end, a "To Be Considered" category (TBCs) was also established for the RI/FS. A listing of potential ARARs and TBCs has been included as Appendix A of this Task 12 Report.

TABLE ES-1
ALTERNATIVE EVALUATION MATRIX

1 = Poor 3 = Average 5 = Good
2 = Below Average 4 = Above Average

Alternative	0	1	2	3	4	5	6	7	8	9
Short-Term Public Health	0	5	3	4	3	3	2	2	3	2
Short-Term Environmental Protection	0	5	3	4	3	3	2	2	3	2
Long-Term Public Health	0	1	3	3	4	2	2	5	2	5
Long-Term Environmental Protection	0	1	4	3	4	2	3	5	2	5
Reduction In Mobility, Toxicity, and Volume	0	3	4	3	3	3	4	4	5	5
Constructability	5	5	3	3	3	2	3	3	3	3
Reliability	2	4	3	5	4	2	5	4	5	4
Maintenance	5	3	3	3	5	3	3	5	3	5
Agency Approvals	0	2	2	2	3	1	2	3	2	3
Special Engineering & Equipment	5	5	1	3	3	3	3	3	2	2
Summation	17	34	29	33	35	24	29	36	30	36

1.0 INTRODUCTION

1.1 PURPOSE

In accordance with the Remedial Investigation/Feasibility Study (RI/FS) Work Plan (Revision 3) for the Feed Materials Production Center (FMPC) at Fernald, Ohio, distinct tasks have been established. There are three tasks: (1) to develop remedial action alternatives and to screen technologies; (2) to refine, evaluate and screen alternatives; and (3) to conduct a detailed analysis of screened alternatives.

The purpose of this report is to document the refinement, evaluation, and screening of the identified remedial action alternatives for the K-65 silos (Silos 1 and 2) and the metal oxide silo (Silo 3) of Operable Unit 4. During the performance of the Task 2 aquifers, Silo 4 was not considered a part of the Operable Unit 4 Feasibility Study. The alternatives are further developed and refined to provide the necessary differentiation required for the evaluation. The alternatives are then evaluated for effectiveness, implementability, and cost, followed by the alternative screening process to determine which should be carried forward for detailed analysis in a subsequent task. In accordance with U.S. Environmental Protection Agency, "Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA," (OSWER Directive 9355.3-1) this report also identifies additional data considered necessary for the detailed analysis and subsequent selection of a preferred action.

1.2 ORGANIZATION OF REPORT

This report will first introduce the alternatives identified in the previous task. Section 2.0 will discuss the refinement of technologies that has occurred since the previous task. Section 3.0 reviews the development of alternatives as well as the remedial action objectives and general response actions. Section 4.0 will address the methodology for and the thought process behind the alternative screening process. This will include a discussion of the requirements for alternative development, evaluation, and screening as outlined in OSWER Directive 9355.3-1. In addition, Section 4.0 also discusses treatment and on-site/off-site disposal considerations. Section 5.0 will present the refinement and evaluation of the alternatives as they are rated against the evaluation criteria. Section 6.0 will rank the alternatives, recommend those alternatives for consideration in the subsequent detailed analysis of alternatives, and discuss additional data requirements.

1.3 BACKGROUND

On July 18, 1986, a Federal Facility Compliance Agreement (FFCA) was jointly signed by the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA) pertaining to the environmental impacts associated with the FMPC. The FFCA was entered into pursuant to Executive Order 12088 to ensure compliance with existing environmental statutes and implementing regulations. In particular, the FFCA was intended to ensure that environmental impacts associated with past and present activities at the FMPC are thoroughly and adequately investigated so that appropriate remedial response actions can be formulated, assessed, and implemented. Subsequent to the oral presentation of the Initial Screening of Alternatives for Operable Unit 4 in June 1989, a CERCLA Section 120 Consent Agreement was executed.

In response, a site-wide RI/FS is in progress pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) 42USC9601. The performance of the RI/FS is in conformance with current EPA guidance and the guidelines, criteria, and considerations set forth in the National Contingency Plan (NCP) 40CFR300 and the Superfund Amendments and Reauthorization Act (SARA) 42USC11001 et. seq. of 1986.

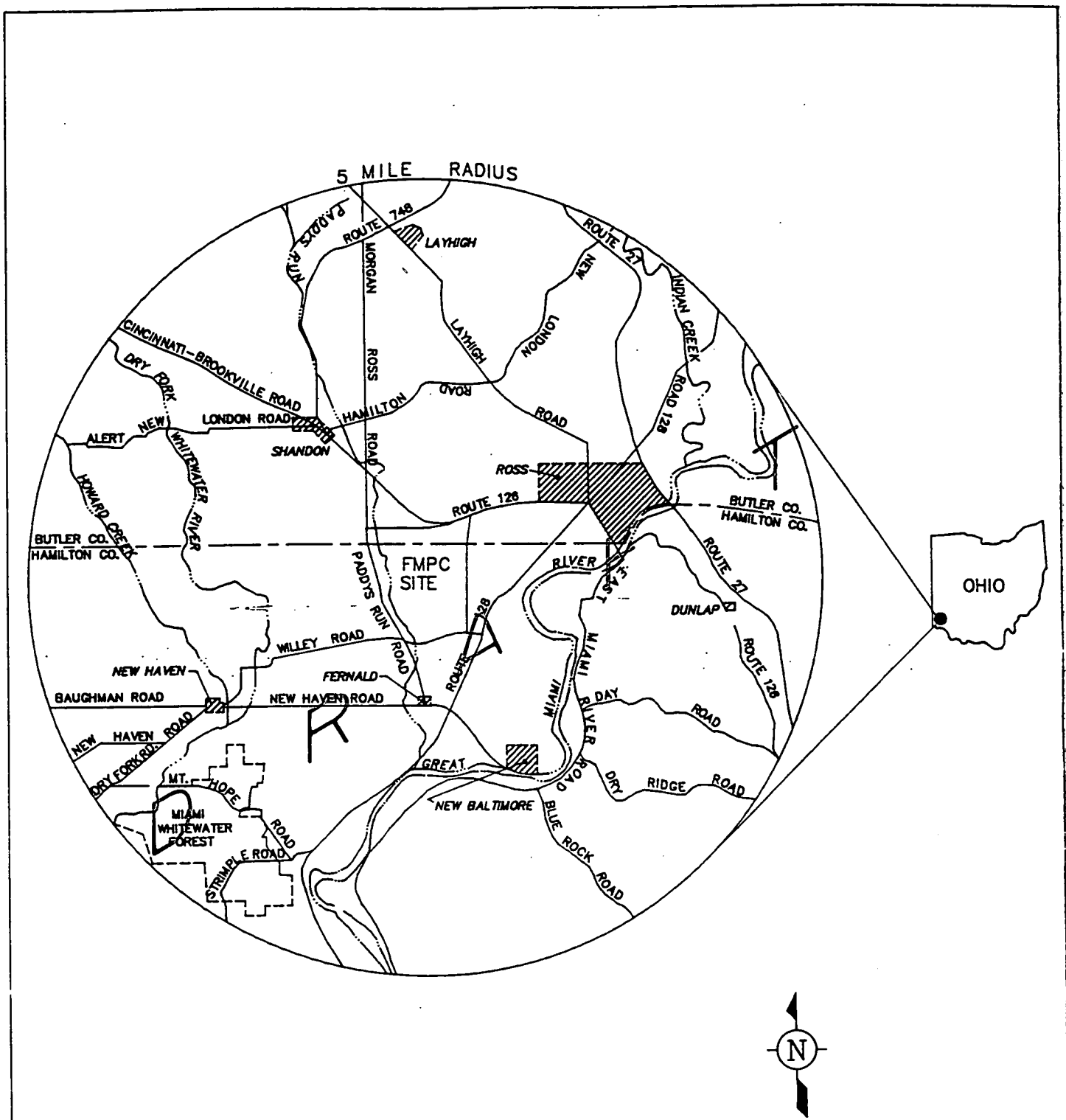
1.3.1 Site Description

The FMPC is a uranium metal production facility located near Fernald, Ohio, approximately 20 miles northwest of Cincinnati (Figure 1-1). The site covers approximately 1050 acres and is used for the production of uranium metal cores, target element cores, and the interim storage of low-level radioactive and mixed wastes. In addition to uranium production facilities, the site also contains waste storage facilities consisting of waste pits, storage silos, a burn pit, a clearwell, two fly ash piles, a sanitary landfill, and lime sludge ponds (Figure 1-2).

1.3.2 Operable Unit Description

Operable Unit 4 consists of the K-65 silos (Silos 1 and 2) and the metal oxide silo (Silo 3) located south of the waste pit area (Figure 1-3). Silo 4, although an element of Operable Unit 4, was never used and is not being considered in this phase of the Feasibility Study for Operable Unit 4.

All four domed waste storage silos are 80 feet in diameter, 36 feet high to the center of the silo dome, and 27 feet high to the top of the vertical walls. The walls are 8-inch concrete, as are the outer part of the domes, which taper to 4 inches in thickness at the center. The floor consists of 4-inch concrete over an underdrain system. This underdrain system consists of a 2-inch slotted pipe in an 8-inch gravel layer underlain by concrete and compacted clay. The entire K-65 silo exteriors



3317A148.DWG

FIGURE 1-1. 5 MILE RADIUS MAP, FEED MATERIALS PRODUCTION CENTER

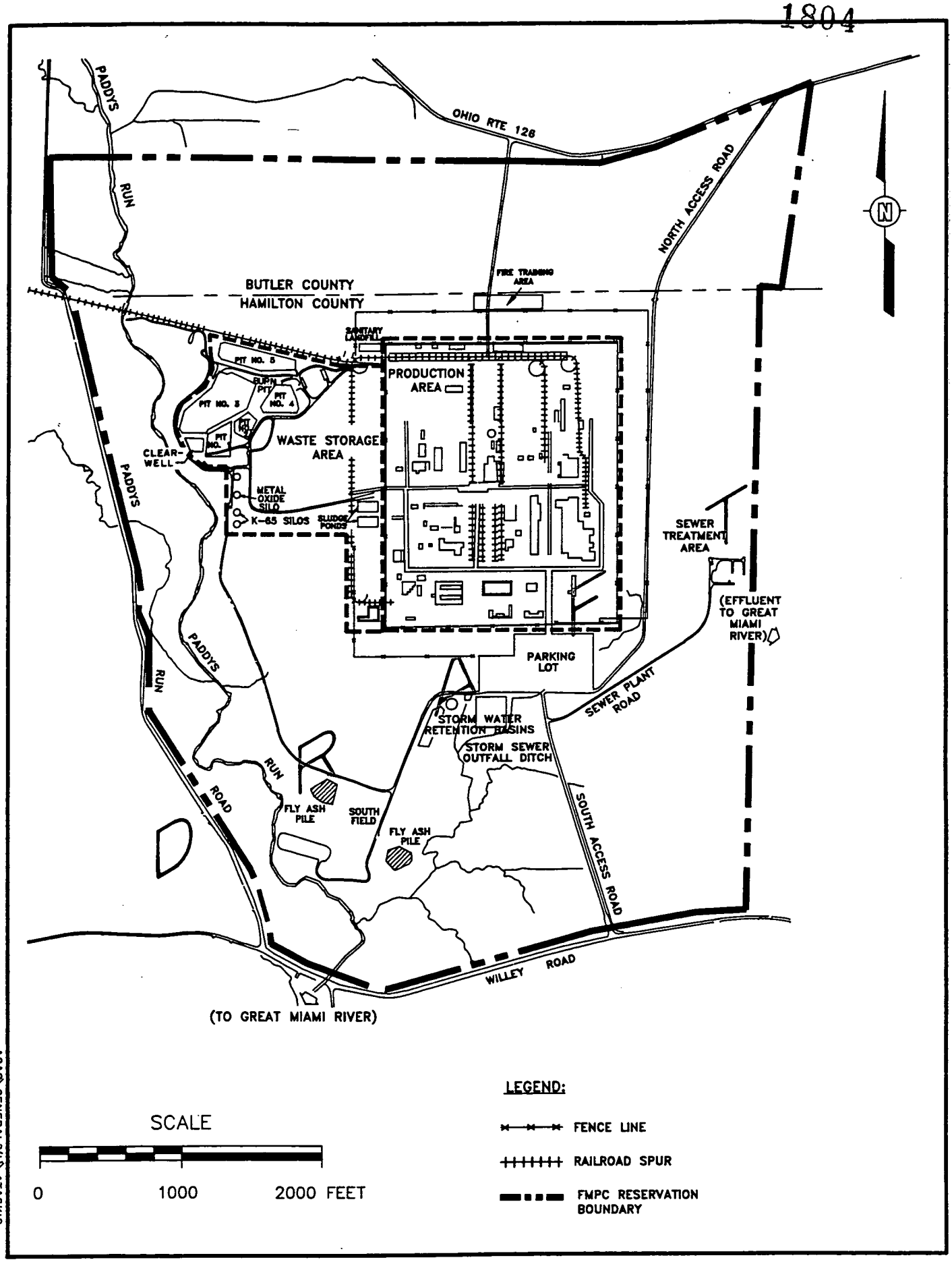


FIGURE 1-2. MAJOR FEATURES OF THE FEED MATERIALS PRODUCTION CENTER

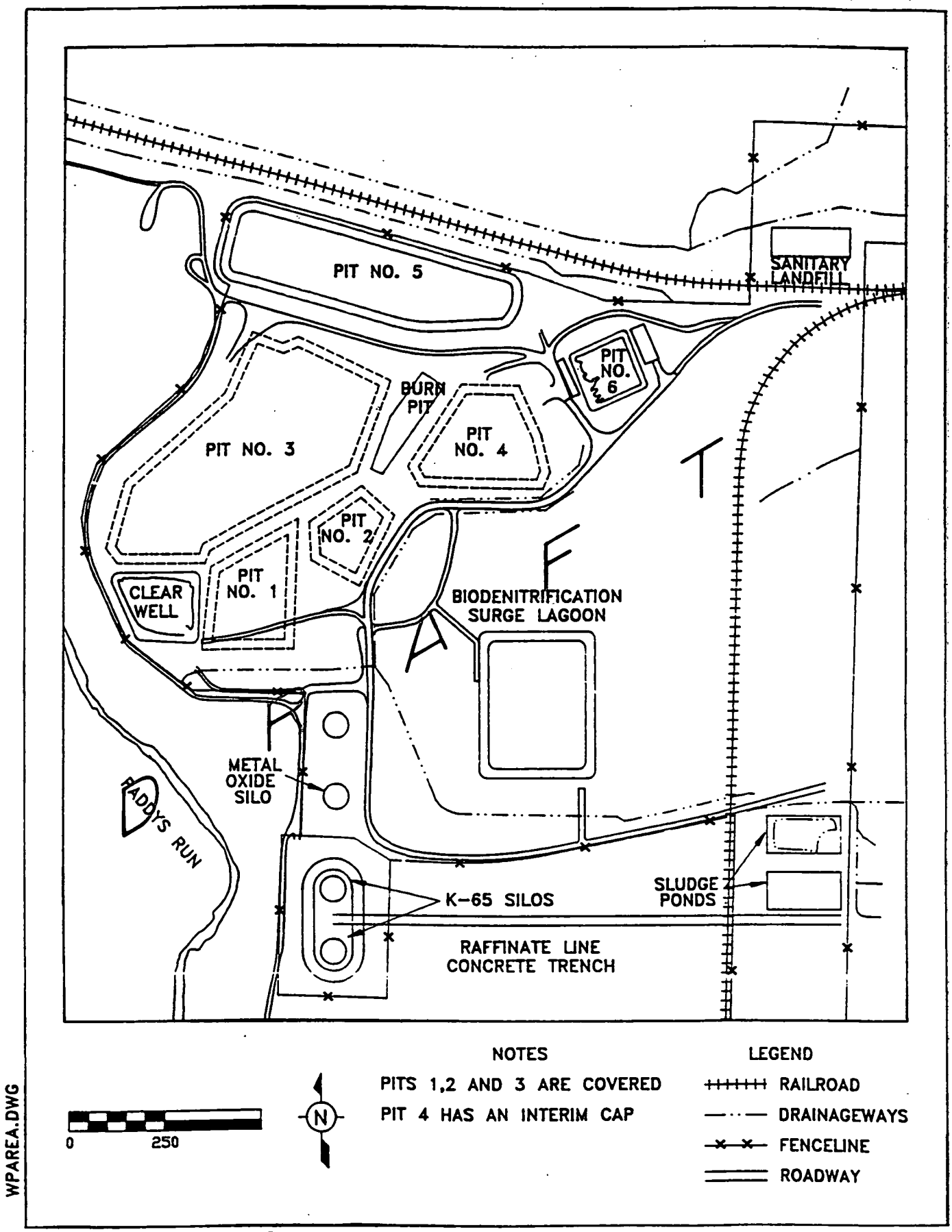


FIGURE 1-3. WASTE STORAGE AREA

have been coated with 0.75 inch of gunite and are surrounded by an earthen berm to a height of approximately 26 feet, while the Silo 3 is free-standing (Figures 1-4 and 1-5).

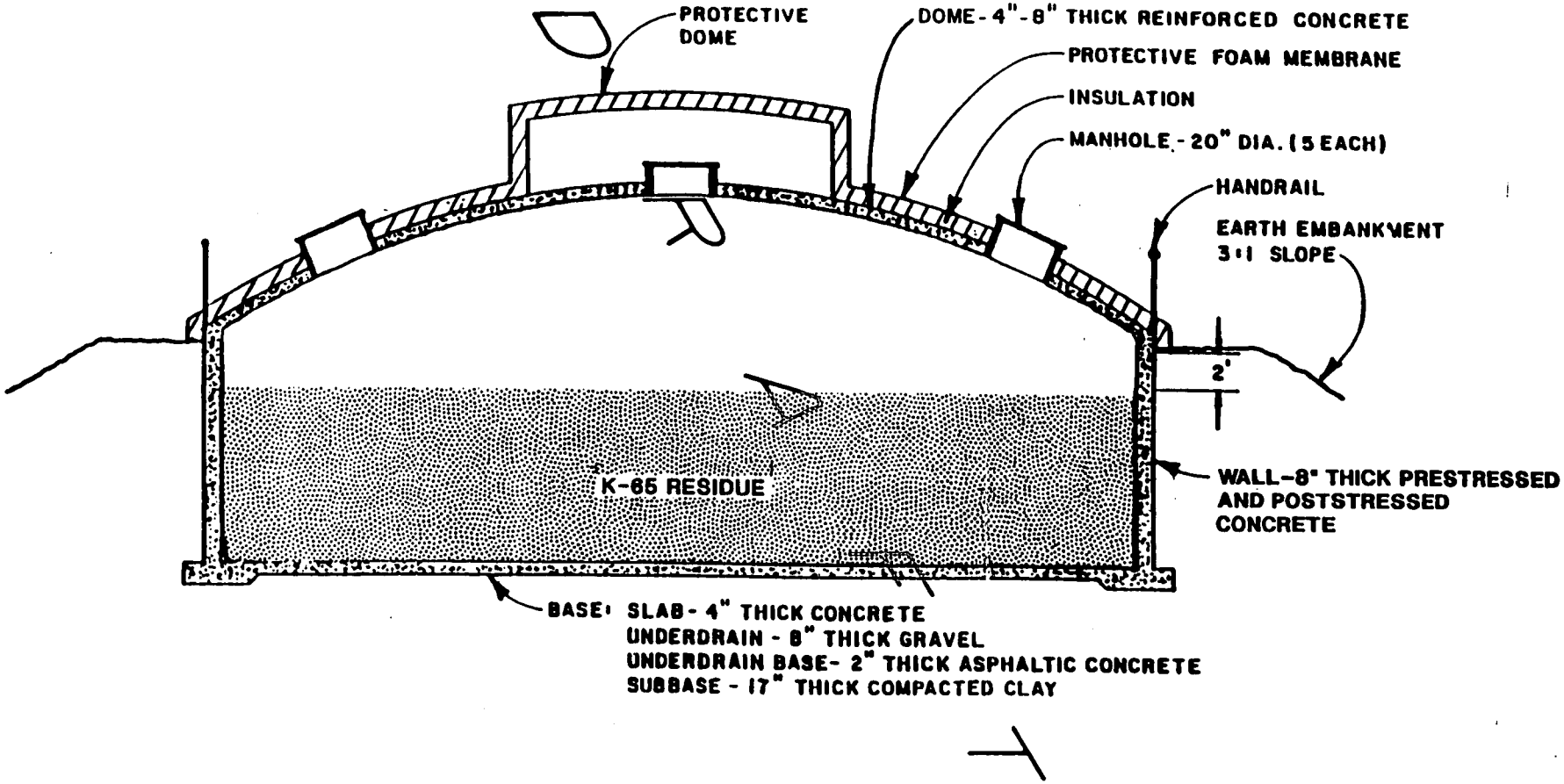
The K-65 silos are used for the storage of radium-bearing residues formed as by-products of uranium ore processing. Silos 1 and 2 received waste residues from 1952 to 1958. Waste raffinates were pumped into the silos, where the solids would settle. The free liquid was decanted through a series of valves placed at various levels along the height of the silo wall. Settling and decanting continued until the silos were filled to approximately 4 feet below the top of the vertical wall.

Corrective actions have been performed in the past to maintain the integrity of the K-65 silos. These include repairing the walls and constructing a berm on a 1-1/2 to 1 slope (mid 1960s) and enlarging the berm to a 3 to 1 slope in the early 1980s. In 1985 a structural assessment was performed. This assessment revealed that the walls and base slab are structurally stable and can function as a containment of dry solids for a period of 10 to 15 years. However, the center 20-foot section of the dome was determined to be structurally unsound for a load greater than the existing static load (Camargo, 1986). Remedial actions taken since 1985 include placement of protective covers constructed of steel and plywood over the center portion of each K-65 silo dome. Three inches of rigid polyurethane foam topped by a 45-mil waterproof, ultraviolet-resistant, urethane-finish coating was placed over each K-65 silo dome in 1987 to provide weather protection and insulation. During the installation process, a temporary radon removal system was implemented to reduce radiation exposure to the workers.

Silos 3 and 4 were constructed in 1952 in a manner similar to Silos 1 and 2; however, the silos were designed to receive dry materials only. Waste raffinate slurries from refinery operations were dewatered in an evaporator and spray-calcined to produce a dry waste form for storage in the silo. The waste was blown in under pressure to fill Silo 3, but Silo 4 was never used and remains empty today.

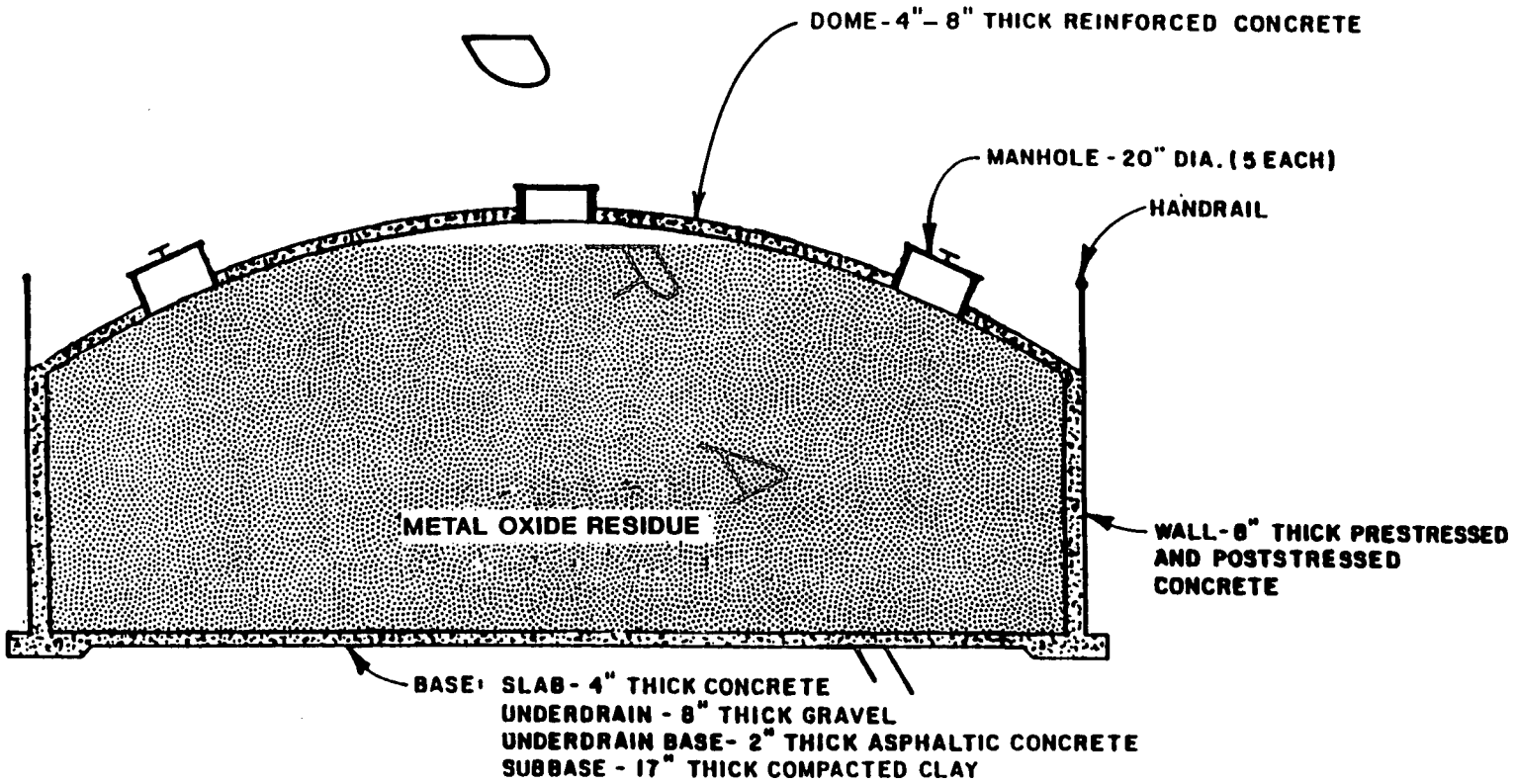
1.3.3 Nature and Extent of Contamination

The primary radioactive constituents of Silos 1 and 2 are radium (Ra-226), radon (Rn-222), uranium (0.71 weight percent U-235), and thorium (Th-230). The majority of the waste material is silica and metallic compounds. Table 1-1 lists the silos constituents and their approximate quantities, based on past sampling efforts. Tables 1-2 and 1-3 summarize the results of the current sampling efforts. Documentation of the past sampling efforts is included in the reference section.



3033017-A-G30
3-9-90 REV. 0

FIGURE 1-4. TYPICAL CROSS-SECTION THROUGH SILOS 1 AND 2



303317-A-G29
3-12-90 REV. 0

FIGURE 1-5. CROSS-SECTION THROUGH SILO 3

1804

TABLE 1-1
SILO WASTE CHARACTERISTICS

	Silos 1 and 2			Silo 3
Characteristic	Litz[a]	NLO[b]	Vitro[c]	DOE[d]
Moisture content (wt %)	-	-	30	-
Dry wt, kg	-	8.79×10^6	1.59×10^6	-
Estimated volume, m^3	-	5,522	3,155	3,902
Density, kg/m^3	-	-	1,179	-
Uranium, ppm	1,800 - 3,200	600	2,110	-
Lead, ppm	60,000 - 70,000	48,000 - 52,000	94,900	-
Radium, ppb	280 - 360	200	300	-
Barium, ppm	50,000	-	45,300	-
Iron, ppm	13,000 - 18,000	-	-	-
Gold, ppm	65 - 78	<40 - 60	-	-
Platinum, ppm	0.9 - 1.4	-	-	-
Palladium, ppm	13 - 18	-	-	-
Silver, ppm	18	<20	-	-
Copper, ppm	500 - 800	400 - 600	-	-
Cobalt, ppm	1,600 - 2,000	1,500 - 2,000	-	-
Nickel, ppm	3,500 - 3,700	2,000 - 3,000	-	-

Source: [a]Litz, J.E., 1974, "Treatment of Pitchblende Residues for Recovery of Metal Values," Hazen Research, Inc., for Cotter Corp., Canon City, CO.

[b]NLO, Inc, and Battelle Columbus Laboratories, 1980, "Scoping Investigation of Short-Term and Long- Term Storage Costs for Afrimet Residues-NFSS and FMPC," Report to the U.S. Dept. of Energy, Remedial Action Program Office, Washington, D.C.

[c]Vitro Corp., 1952, "Summation Report: Recovery of Radium from K-65 Residue," U.S. Atomic Energy Commission, KLX-1222.

[d]U.S. Department of Energy, 1987, "Remedial Investigation and Feasibility Study, Feed Materials Production Center, Fernald, Ohio, Task 1 Report: Description of Current Situation," DOE, Oak Ridge Operations Office, Oak Ridge, TN.

TABLE 1-2
RADIONUCLIDE CONCENTRATION SUMMARY IN THE SILOS

Nuclide (pCi/g)	Silo 1	Silo 2	Silo 3
Ac-227	NA	NA	234 - 1363
Pa-231	NA	NA	266 - 931
Th-228	ND	ND - 638	ND - 996
Th-230	10,569 - 43,771	8365 - 40,124	21,010 - 71,650
Th-232	ND - 766	ND - 851	ND - 1451
Ra-224	NA	NA	64 - 453
Ra-226	89, 280 - 192,600	657 - 145,300	467 - 6435
Ra-228	ND	ND	ND - 559
Pb-210	48,980 - 181,100	77,940 - 399,200	454 - 6427
U-234	326 - 897	129 - 1404	348 - 1935
U-235/236	ND - 56	ND - 74	ND - 158
U-238	398 - 920	46 - 1240	320 - 2043
U-Total (ppm)	1189 - 2753	137 - 3717	738 - 4554

NA = Not Analyzed
ND = Not Detected

Note: Data validation is currently in progress
Source: Winter 1989 WMCO sampling

TABLE 1-3
CHEMICAL CONCENTRATIONS IN THE SILO WASTE

Contaminant	Silo 1 (µg/kg)	Silo 2 (µg/kg)	Silo 3 (µg/kg)
PCB Organics Analysis Data			
Aroclor-1248	ND - 8000	ND	ND
Aroclor-1254	1100-12000	420 - 6000	ND

Contaminant	Silo 1 (mg/kg)	Silo 2 (mg/kg)	Silo 3 (mg/kg)
Inorganic Analysis Data			
Aluminum	60.4 - 1430	464 - 2570	10,800 - 23,700
Antimony	ND	ND - 7.2	ND
Arsenic	14.7 - 68.4	57.5 - 1960	532 - 6380
Barium	1970 - 7860	89.2 - 8370	118 - 332
Beryllium	0.88 - 2.8	0.66 - 6.0	10.0 - 39.9
Cadmium	2.1 - 8.0	3.4 - 19.1	21.5 - 204
Calcium	2150 - 5700	2430 - 301,000	21,300 - 39,900
Chromium	21.0 - 165	12.9 - 68.8	139 - 560
Cobalt	349 - 1260	6.2 - 2430	ND - 3520
Copper	122 - 473	ND - 1790	1610 - 7060
Iron	4340 - 75,100	4010 - 37,800	13,900 - 67,600
Lead	35,800 - 85,100	153 - 29,800	646 - 4430
Magnesium	1500 - 6020	1520 - 8740	38,200 - 80,900
Manganese	33.5 - 257	74.2 - 403	2420 - 6500
Mercury	0.23 - 2.8	ND - 2.3	ND - 0.69
Nickel	629 - 2580	14.6 - 2200	1200 - 6170
Potassium	158 - 492	37.8 - 289	1300 - 22,800
Selenium	106 - 180	ND - 118	101 - 349
Silver	5.0 - 23.3	ND - 22.8	9.2 - 23.8
Sodium	360 - 13,100	226 - 4070	22,900 - 51,700
Thallium	ND - 0.52	ND - 1.4	3.1 - 73.9
Vanadium	72.2 - 240	21.9 - 214	418 - 4550
Zinc	14.4 - 212	11.2 - 154	301 - 672
Cyanide	0.52 - 4.4	ND - 4.5	ND

ND = Not Detected
Note 1: All detected volatile and semivolatile compounds resulted from laboratory contamination or are at or below the contract required quantification limits (CRQL)
Note 2: Data validation is currently in progress
Source: Winter 1989 WMCO sampling

Radon and the elements resulting from its decay (daughter products, progeny, etc.) are the nuclides of concern from a health and environmental perspective. Radon is known to be diffusing out of the silos via cracks and structural joints. Radon and its daughter products are relatively mobile and capable of migrating through air and water; there is no evidence to date that any of the other contaminants have migrated. Due to the diffusion of radon into the berms, it is believed that the berms and subsoils contain elevated levels of Pb-210 and Po-210. The Pb-210 and Po-210 resulted from the decay of radon which diffused into the berm. There may have been leakage from the existing leachate collection system beneath the silos into the surrounding soils. Sampling of the berms and soil beneath the silos is scheduled, and upon completion will confirm the nature and extent of contaminant migration, if any.

Silo 3 contains uranium (0.71 weight percent U-235), thorium (Th-230), silica, a very small amount of radium (Ra-226), and other metal oxides. Silo 3 is not a significant radon source, and, due to the physical characteristics of the waste (dry and powdery), it is not believed to be the source of any contaminant migration to the surrounding and underlying environs. It is, however, still a source of radioactive waste and a potential airborne contaminant hazard due to its dry, powdery consistency.

DRAFT

2.0

2.0 TECHNOLOGY AND PROCESS OPTION REFINEMENT

A number of technologies were introduced in the previous task which were relatively unrefined or undeveloped. There has been substantial development for several of these technologies into process options which allows an effective evaluation and screening of alternatives. These technologies and process options, in addition to those that were sufficiently developed in the previous task, are described in the following sections.

2.1 ENVIRONMENTAL ISOLATION ENCLOSURE

Prior to initiating any waste removal or in situ waste treatment alternatives, an environmental isolation enclosure (EIE) will be constructed to enclose the K-65 silos and/or Silo 3 and the surrounding work area (Figure 2-1). The purpose of the enclosed facility is to create an isolated environment, thereby protecting the public, other site workers, and the environment from the contamination hazards associated with silo demolition and waste removal.

The EIE is a variation of the temporary storage structure (TSS) technology. The EIE could be either a tension arch structure with negative internal pressure or a double-layered, positive internal pressure (inflatable), stabilized cable structure. Either design will incorporate equipment and manway airlocks as well as a remote-controlled bridge crane system over the silos. All exhausted air from the EIE will be filtered to meet site-specific discharge limits.

The EIE is required only for the time needed to support remediation efforts. The facility will be designed to withstand 100 mile per hour winds and include redundant safety systems such as a standby electrical power generator and HVAC.

The construction of the EIE requires:

- Silo berm modifications (Figures 2-2 and 2-3)
- Utility and general construction/remediation support services at both interior and exterior work staging areas
- EIE foundation
- Bridge crane system (Figures 2-1 and 2-3), structural steel box girder frame with low bearing pressure grade beams or conventional footing foundations
- Remote-controlled traveling bridge crane with dual lifting hoists for each silo
- Remote-controlled video camera with tilt and pan capabilities for each silo

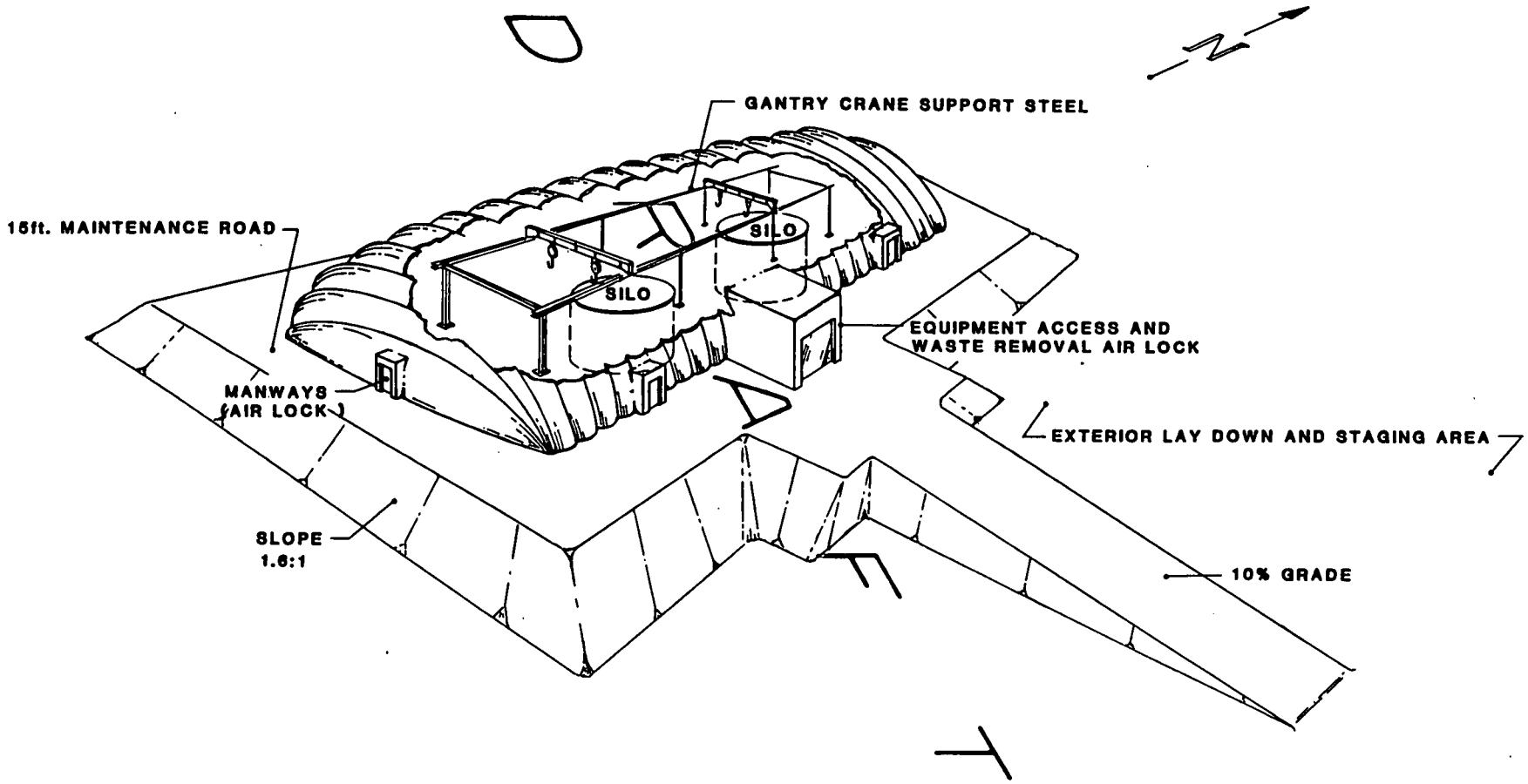
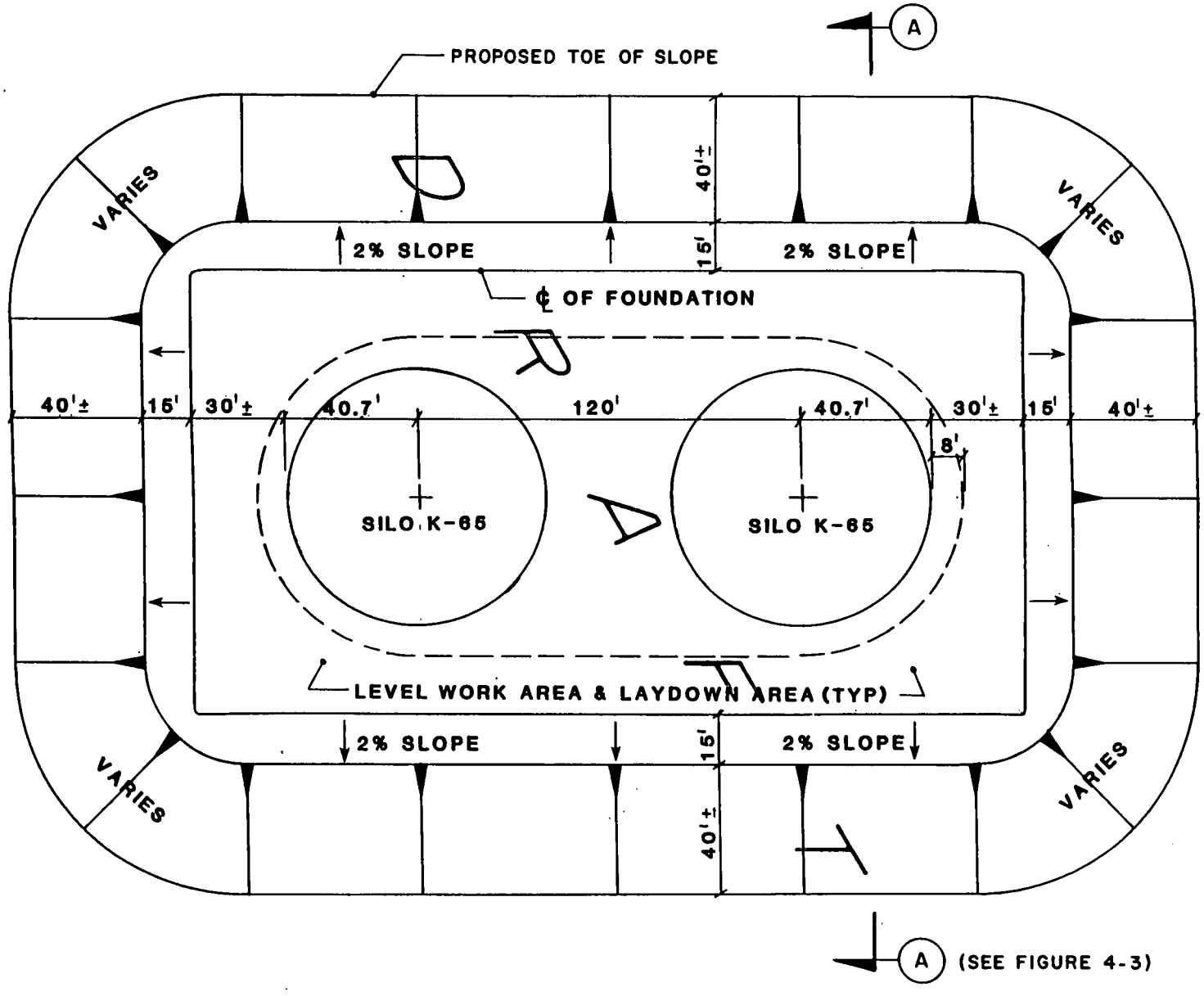
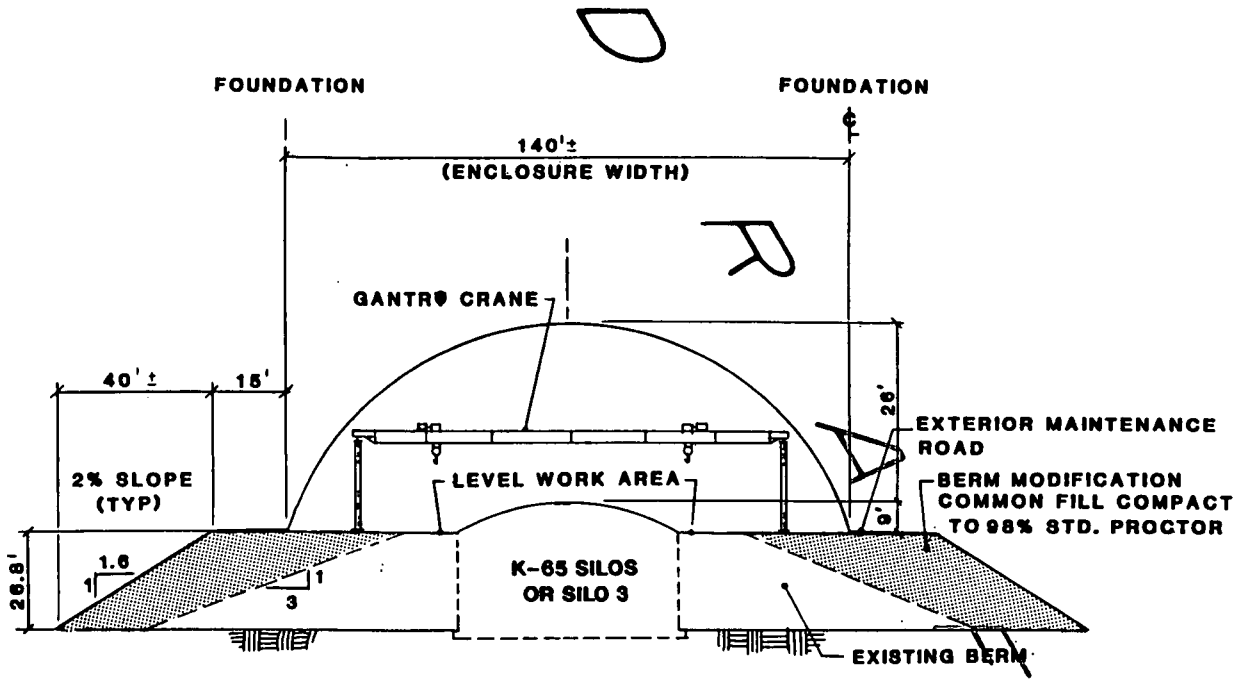


FIGURE 2-1. CONCEPTUAL VIEW OF ENVIRONMENTAL ISOLATION ENCLOSURE (EIE) OVER K-65 SILOS



303317-B-C09
3-12-90 REV. 0

FIGURE 2-2. PLAN VIEW OF EIE AND BERM MODIFICATION



NOTES:

1. DESIGN EIE STRUCTURE FOR 100 MPH STORM
2. SILO 3, EIE, PRESENTLY HAS NO BERM, THEREFORE WOULD REQUIRE ADDITION OF ENOUGH FILL SOILS TO CONSTRUCT PROFILE SHOWN ON SECTION A-A
3. SILO 3 EIE DIMENSIONS ARE 140' X 140'
4. EQUIPMENT & PERSONNEL ACCESS AIR-LOCK DETAILS NOT SHOWN
5. BERM MODIFICATIONS & GENERAL EIE DIMENSIONS MAY BE GREATER THAN SHOWN DUE TO UNKNOWN CONDITIONS
6. AIR TREATMENT SYSTEM DETAILS NOT SHOWN

DRAFT

303317-B-C11
3-12-90 REV. 0

FIGURE 2-3. SECTIONAL VIEW OF EIE, SECTION A-A

- Positioned and preassembled specialized remediation equipment inside the designated interior staging area

- Installation of HVAC system
  - High efficiency particulate absolute (HEPA) filters, carbon adsorbers, dehumidification equipment
  - Localized radon removal system, if necessary

- Installation of equipment and personnel airlocks; main equipment airlock should be constructed on east side between silos

- Equipment access ramp at maximum grade of 10 percent

- Installation of an activities control center inside the EIE in a non-obstructive location to facilitate waste handling activities, to include:
  - Video monitor and camera controls
  - Crane system controls
  - Alarm and general monitoring equipment
  - Communications equipment
  - Radiation shielding, separate air supply, and separate manway leading to the exterior of the EIE

During EIE construction, similar pressurized enclosures could be erected in the exterior staging area to provide containment for waste transfer, storage, and/or treatment activities.

2.2 MECHANICAL, HYDRAULIC, PNEUMATIC REMOVAL

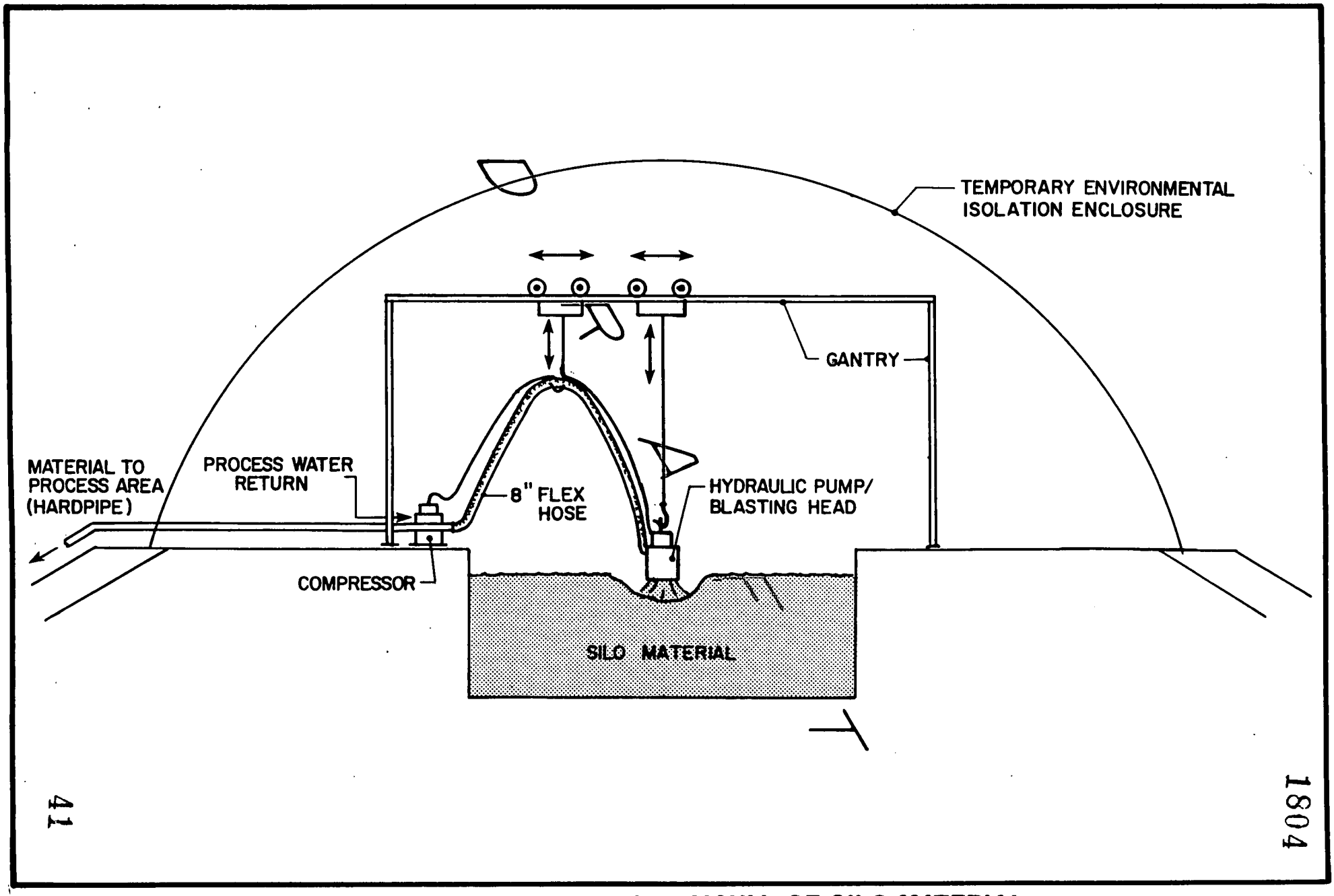
2.2.1 Mechanical Removal

Mechanical removal will require the use of an overhead gantry hoist equipped with a clamshell or bucket capable of transferring the silo contents either directly into containers or onto a closed belt or bucket-type conveyor system for transport to a packaging facility. The major pieces of equipment required are:

- Remotely operated front-end loaders
- Gantry supported clamshell
- Closed belt or bucket-type conveyor system

2.2.2 Hydraulic Removal

The hydraulic removal option adds water to the silo contents to achieve a slurry that can be removed by dredge, slurry pump, or similar piece of equipment (Figure 2-4). A system will be installed to ensure that the water used for "mining" the silo contents does not leak into the surrounding ground and surface waters (i.e., liners, water collection equipment, etc.). The slurry



303317-A-M12
3-9-90 REV. 0

FIGURE 2-4. HYDRAULIC REMOVAL OF SILO MATERIAL

will then be pumped to solid/liquid separation equipment in the process building which provides filtration, centrifugation, sedimentation, drying, evaporation, or other similar operations to remove the liquid. The dried sludge will be transferred to a packaging area and the contaminated water will be recycled to the mining head or used in the solidification process. The actual equipment to support this type of removal will be determined by slurry composition and final disposition of the sludge. The major pieces of equipment required are:

- Combination blasting/suction hydraulic mining tool
- Mechanical cutter head
- Double-walled suction line (8 inch flexible hose)
- Centrifuge, evaporators, and/or calciners

2.2.3 Pneumatic Removal

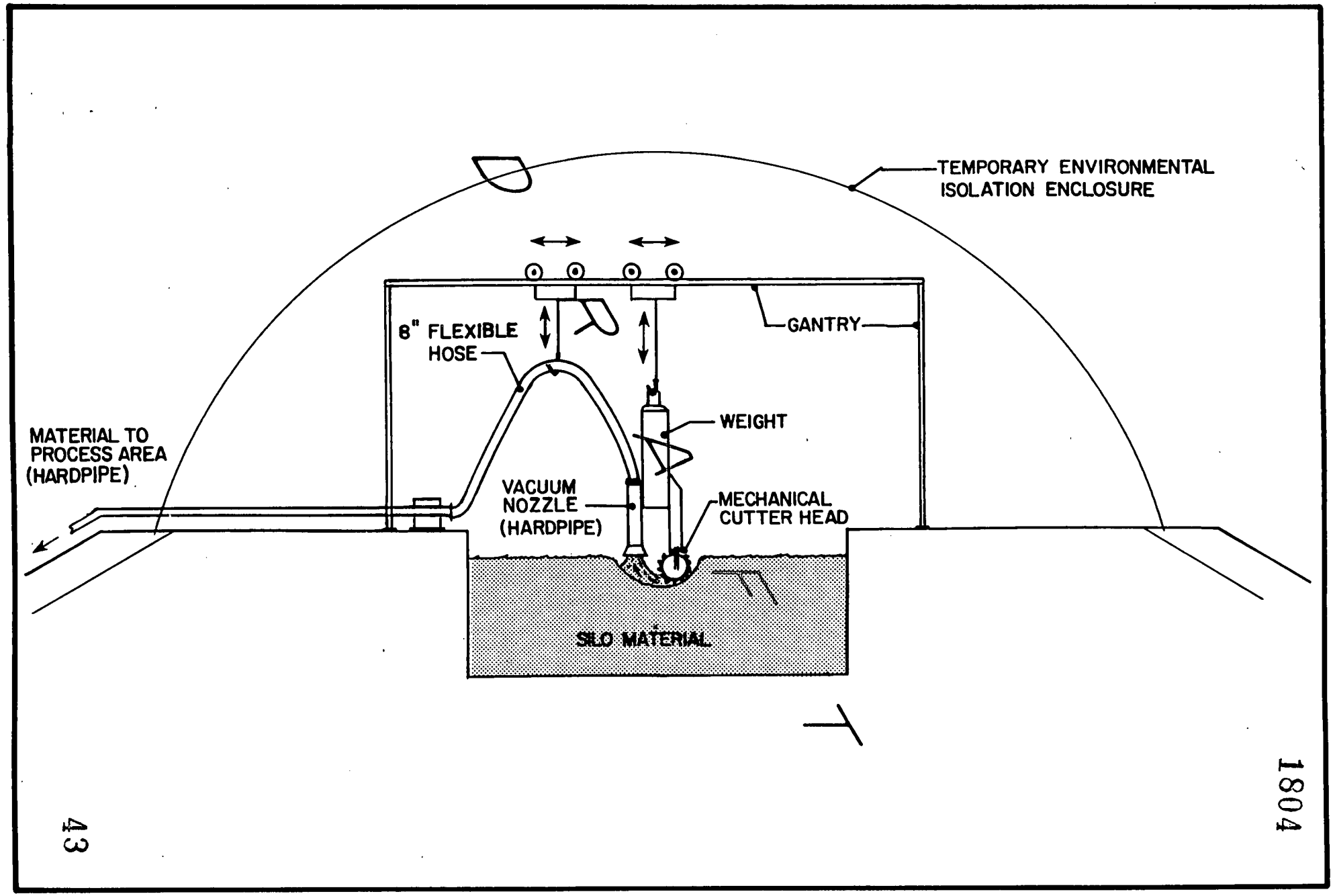
The pneumatic removal method involves the use of a mechanical cutter and an airlift to entrain the material in an airstream routed to a temporary storage system for separation of solids (Figure 2-5). This separation scheme utilizes filters, cyclone separators, and dust collectors, among other devices. The waste is routed to a packaging facility and the filtered air is recycled to the removal system or discharged. All operations will be conducted in closed vessels and all vents will be equipped with HEPA filters and carbon adsorbers (if necessary) for emission control. The major pieces of equipment required are:

- Rigid pipe suction nozzle
- Mechanical cutter head
- Double-walled suction line (8 inch flexible hose)
- Cyclone separators, baghouse, HEPA filters

2.3 SILO DEMOLITION

Five technologies are listed below which could be utilized for the demolition of the K-65 silos and Silo 3. A short discussion listing the relative disadvantages or advantages of each technology is provided. The concrete walls are approximately eight inches thick with wire-wound post-tensioned steel. The walls also have vertical prestressed steel tendons spaced around the wall, as well as deformed reinforcing steel bars. It may be possible to clean the inner surface of the silo prior to demolition.

- Headache Ball:
  - This method utilizes a large steel ball attached to a crane which has been proven to be an effective means to demolish concrete tanks such as the silos. This technique requires cutting the steel wire and rebar with a gas torch once the concrete is demolished. The major drawback to this method is the substantial dust generation. As it is very likely that this dust would contain radioactive contamination, this option is unsuitable.



303317-A-M13
3-12-90 REV. 90

FIGURE 2–5. VACUUM REMOVAL OF SILO MATERIAL

- Explosive Charges:
  - This method is quite effective; however, it would create airborne radioactive contamination and excessive ground vibration and is therefore an unsuitable option.

- Hydraulic Splitter:
  - This method is effective in cutting both concrete and steel. The operation can be conducted remotely to prevent the possibility of injury to workers due to unexpected collapse of the silo. This method does not generate airborne contamination as no dust is created. Water used to cut the concrete requires collection and possible treatment as it may become contaminated.

- Nonexplosive Demolition Agent:
  - This method involves drilling a hole pattern into the silo and placing a demolition agent inside the holes. When mixed with water, the agent expands and breaks the concrete. This technique requires cutting with a torch, creates no dust, and is cost-effective when used to split the silo into large pieces.

- Gas Torch:
  - A gas torch (similar to or the same type as used to cut steel) can be used to cut both the concrete and steel in the silo. Although this method is effective, it may present a hazard to the workers in the event of a sudden silo collapse unless it is performed remotely.

The demolition methods discussed above will be used inside an Environmental Isolation Enclosure (EIE), with the exception of the headache ball and the explosive charges. Concerns about dust are eliminated by demolition inside such a structure. Other features such as underground piping and tanks also require removal. If an off-site disposal alternative is selected, the concrete rubble and piping must be sized to fit shipping containers. A combination of demolition technologies may be desirable to demolish the silos and reduce the debris to a volume suitable for on- or off-site disposal.

2.4 STABILIZATION/VITRIFICATION

2.4.1 Stabilization

The stabilization technology offers the following possible process options:

- Asphalt encapsulation:
  - Ex situ asphalt stabilization can be achieved by removing the waste to a heated mixer where it can be blended with molten asphalt and extruded into a form. It is expected that activated powdered carbon can be blended with the waste in an attempt to control existing radon emissions and some future emissions. The result of this process is a monolithic product with excellent leach control properties.

- Stabilization with lime, fly ash, and activated carbon reagents:
  - The waste and reagent mixing is done in a cement mixer or covered pug mill equipped to scrub the radon off-gases. No other off-gassing is expected to occur

because no ammonia is present and none of the reagents are expected to be acidic. The waste will then be poured into forms for packaging and disposal.

The activated carbon will help control the off-gassing of radon during and after treatment. The potential for biological activity is very slight given the high expected pH of the mix and the fact that the activated carbon (mostly graphite) is not attacked by bacteria.

- Stabilization with proprietary cement-based technologies:
  - The waste is conveyed to a mixer or pug mill where it is mixed with water, proprietary reagents, and activated carbon. The waste is then poured into boxes or bags for curing before disposal to the disposal facility.

- Stabilization with polymerized organic monomers:
  - For this process option, the waste is mixed in a drum or box with a monomer and an initiating agent or catalyst prior to shipment to the disposal facility.

It is possible to design a completely self-contained system with off-gas control if the mixing of activated carbon in the waste is not determined to be beneficial.

2.4.2 Vitrification

Ex situ vitrification of the waste requires that the water content of the waste be no greater than 30 percent by weight. A water content greater than this can cause foaming problems and increase power requirements. The waste should be dried to reduce the water content to 15 to 20 percent (ideally) so that the waste resembles a fine damp silt.

The dried waste will be conveyed to the vitrification system surge hopper. The vitrification rate will be approximately 50 to 100 tons per day so the surge hopper is sized for approximately 100 tons of waste. All equipment will be under negative pressure and will vent to the facility air pollution control (APC) system which will feature dehumidification and HEPA and carbon filtration.

The glass melter of the vitrification unit could be either a conventional cold cap design, a drop tube device as is used on higher level radwaste, or a mechanically stirred melter. The melter will be electrically heated and designed for minimum emissions of radon, dust, and volatile metals and fumes. The glass from the melter will be cast into steel containers similar to LSA boxes (4- to 6-foot-cubes). The steel containers will be cooled by air and water during casting, and after cooling the boxes will be sealed and placed in the disposal facility.

The vitrification facility will be enclosed in a ventilated process building. The equipment will be designed for remote operation to minimize exposure during operation.

In Situ Vitrification

Following removal of the silo domes the vitrification equipment would be lowered into the domes. The electrodes used in the process would be installed in a grid pattern. Close spacing is required because of the extreme depths (25 feet).

In this process option, fume hoods are installed over the active (melting) settings to capture any contaminated steam generated during the vitrification process. This steam is condensed and treated by an APC system separate from the general building ventilation system. This system removes radon, volatile metals and fumes, and contaminated dust. Electrodes are energized and blocks of waste melted. The melting process is controlled so that all of the silo waste and much of the silo walls are vitrified. The vitrified waste, silo walls, and adjacent portions of the berm form a continuous monolithic mass which does not require additional structural support. Thermocouples are placed along the bottoms of the silo walls to verify the extent of vitrification. Cores may also be drilled into the cooled glass to confirm complete vitrification.

In Situ Chemical Stabilization

This process option stabilizes the waste through the addition of cement and fly ash. Following silo dome removal, these materials are added to the waste and mixed by augers lowered into the silos by a crane. This process is commonly called shallow soil mixing and although it is a relatively new process in this country it has been used extensively in Japan.

Shallow soil mixing can be used to mix portland cement, fly ash, bentonite, or any other stabilizing agent into the waste. Since the waste is somewhat dry, especially in Silo 3, the chemicals are added as a slurry. The amount of stabilizing agent required and the subsequent volume increase depends on the system used and requires treatability studies. If the waste volume is increased by more than 10-20 percent, the berms around the silos must be raised.

Core samples can be drawn to determine that adequate stabilization has been achieved, as previous applications of this technology indicate that nonuniform mixing can be a problem.

2.5 AIR TREATMENT PROCESS

An air treatment system will be installed to minimize radon and radioactive particle emissions to the environment and to maintain airborne contamination levels as low as possible in work area containments. The final design of the air treatment system should assume the existing temporary

radon removal system at the K-65 silos will be upgraded and used to reduce the high equilibrium radon levels in the airspace of each silo to less than 1 curie prior to removing the silo domes. During the design of the existing radon removal system it was determined (by calculation and engineering judgment) that, given the rate of radon emission from the silo waste, the lowest level to which the radon level could effectively be reduced was 1 curie.

Typical air treatment equipment consists of roughing filters, HEPA filters, and carbon adsorption units. The specific arrangement for an air treatment system is dependent on the type of remedial action chosen. Generally, any system providing ventilation for work area containments should be designed to maintain a minimum of six air volume turnovers per hour. Six air volume turnovers per hour was a preliminary estimate of the desired flow rate based on industry standards. This estimate will be refined during Task 13. To supplement the installed ventilation system, any vitrification equipment will need the built-in capability to treat gases generated during the vitrification process. Also, as an option to supplement the general ventilation system, carbon adsorption trains could be installed to provide localized radon removal.

2.6 WATER TREATMENT - METALS REMOVAL, ION EXCHANGE, AND DENITRIFICATION

Water treatment will be required for a wide variety of types, concentrations, and flows of wastewaters. Many of the waters have metals contamination, low-level radioactivity, possible organics, and high nitrate. To treat the relatively concentrated streams, bulk removal methods for metals can be utilized followed by additional treatment with ion exchange and denitrification as necessary.

Concentrated waters will be pH adjusted and treated with chemicals to facilitate precipitation of insoluble metal compounds. Flocculation will allow particle agglomeration to occur. Solids will be separated from the water using one or a combination of methods, depending on the size and concentration of the particles. Clarification, filtration, centrifugation, and flotation can all be considered. Sludges from these operations will be treated with solidification or vitrification.

Effluent from these processes will be further treated using ion exchange to remove residual contaminants. Typically, this will be necessary to treat water with low levels of radioactive metals and should allow direct discharge of the water. Various ion exchange resins can be used that have differing selectivity, depending on the mixture of metals and other ions present in the water. Some resins are regenerated using an acid solution that removes the metals from the resin. This solution

is neutralized and then recycled to the precipitation unit. Other resins are used once and then disposed of as a solidified hazardous and/or radioactive waste.

Some wastewaters may require nitrate removal before they can be discharged. The existing biodenitrification system at the FMPC will likely be used for this service, although new units can be utilized, such as small sequencing batching reactors. Biological denitrification generates clean effluent for discharge, and biological sludge that can be disposed of as part of WMCO's ongoing waste operations program.

Figure 2-6 presents a flow diagram for water treatment.

2.7 IMPERMEABLE CAP

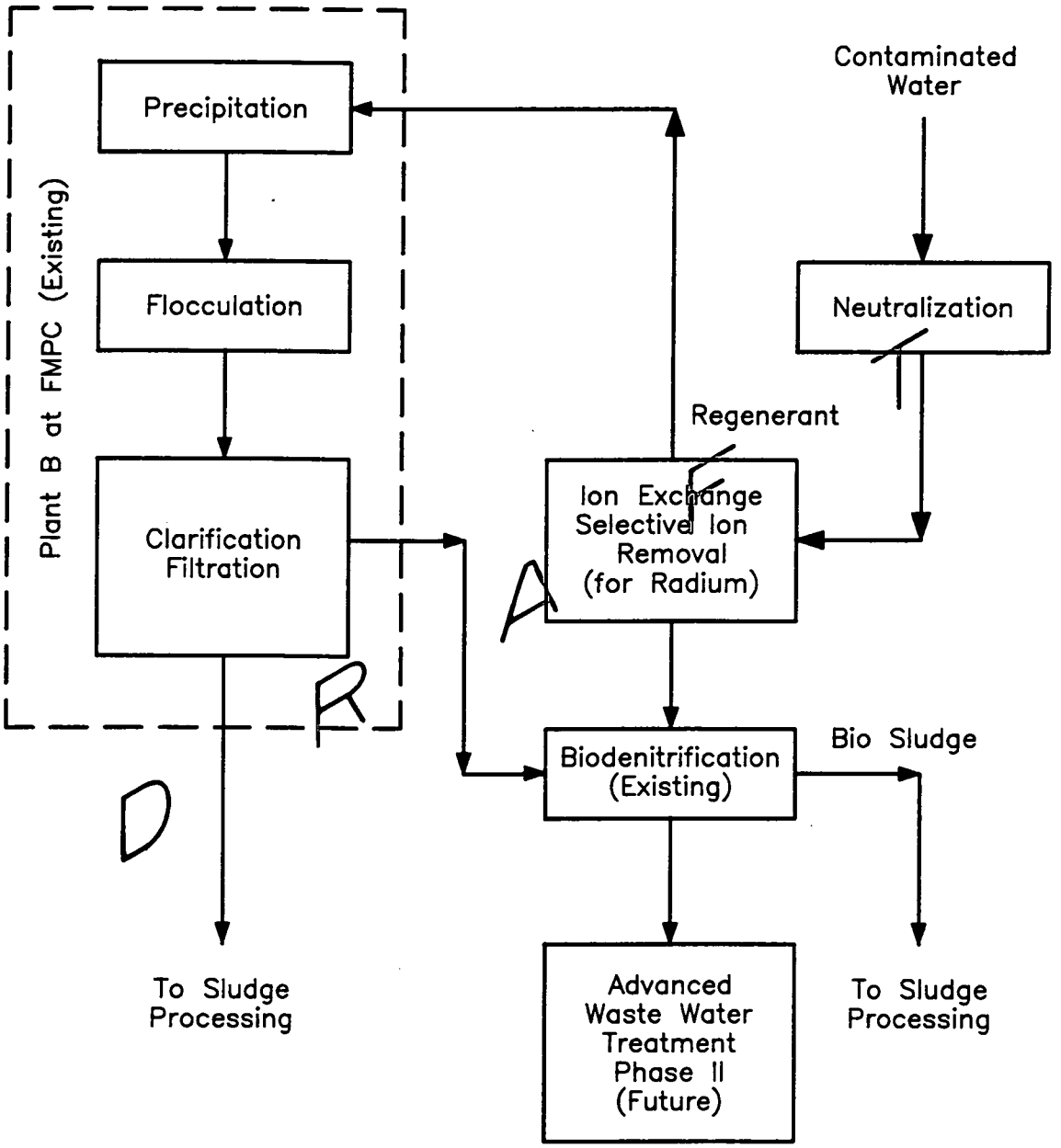
Capping involves the installation of a barrier over the surface of a contaminated area to control erosion and prevent the generation of leachate caused by surface water infiltration. Capping can also alleviate possible direct and/or indirect exposures. It is applicable for source control and containment, and is generally used in combination with other technologies.

Cap design must be in accordance with applicable regulations, including 40CFR264 (Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities), 40CFR61 (National Emission Standards for Hazardous Air Pollutants), and 10CFR61 (Licensing Requirements for Land Disposal of Radioactive Waste). Some of the considerations are:

- Minimum liquid migration through the waste
- Low cover maintenance requirements
- High resistance to damage by settling or subsidence
- Lower or equal permeability than the underlying liner system
- Attain radionuclide emission requirements.

A cap can be single or multiple layers and can consist of asphalt, chemical sealant/stabilizer, clay, concrete, or multimedia. Chemical sealants and stabilizers require a homogenous soil base, are typically feasible for small areas, and can be susceptible to cracking and weathering.

A multiple-layer cap will be utilized for Operable Unit 4 and will be designed in accordance with EPA guidelines under RCRA. The guidelines recommend a three-layer system which consists of:



DRAWINGS\303317.9

FIGURE 2-6. WATER TREATMENT – METALS REMOVAL, ION-EXCHANGE AND DENITRIFICATION

- An upper vegetative layer
- A drainage layer
- A low permeability bottom layer

The vegetative layer will be supported by the topsoil/cover. The drainage layer will consist of sand, and the low permeability layer will consist of a layer of clay with a permeability of less than 1×10^{-7} cm/sec. This design will divert infiltrating liquids away from the enclosed waste materials (Figure 2-7).

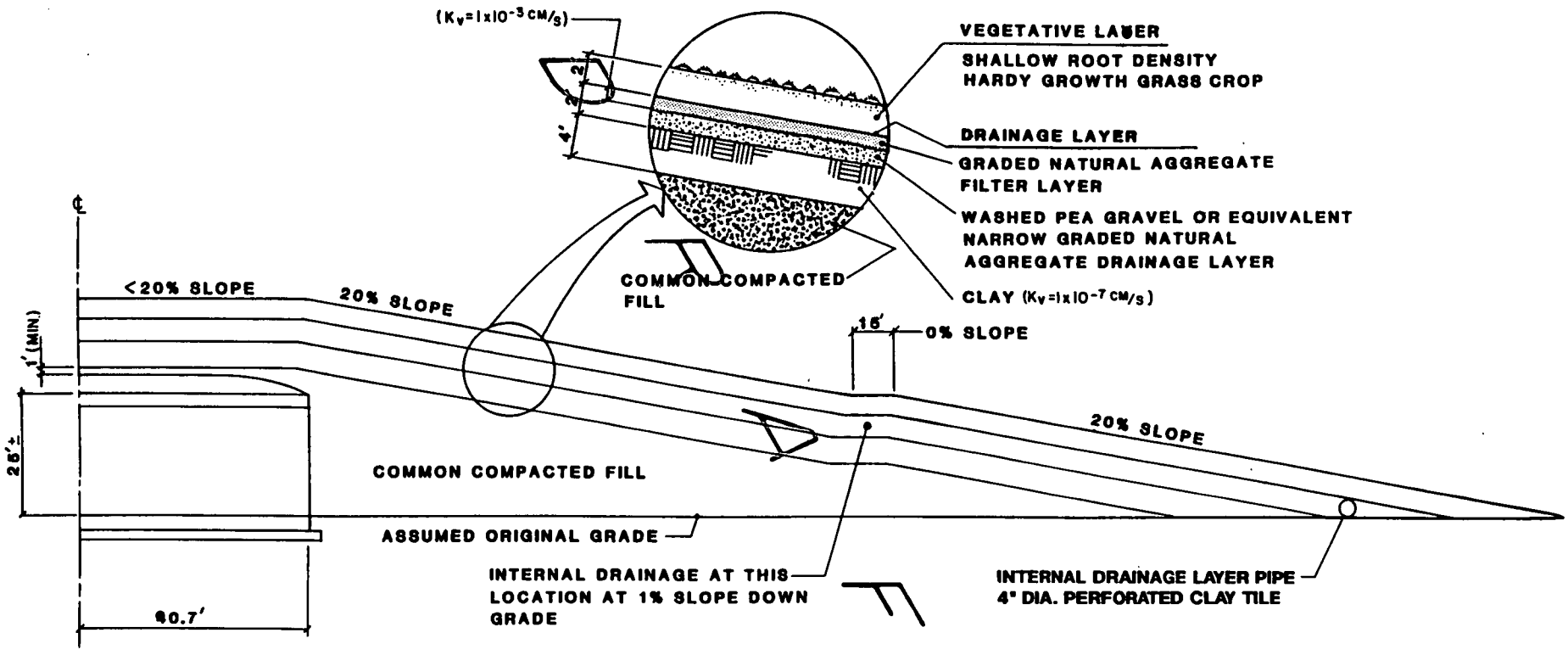
2.8 ON-SITE DISPOSAL FACILITY

A tumulus or aboveground waste disposal facility could be constructed for the on-site disposal of the waste material. The tumulus disposal concept basically consists of mounding over waste which has been placed on a stable structural pad. The aboveground structure is a reinforced vault-like concrete structure designed for permanent waste disposal. For reasons of structural integrity (cap subsidence) and concerns for water infiltration (leaching), both the tumulus and the aboveground structure accept only containerized and highly solidified waste forms. Two design options are being considered for each (Figures 2-8 through 2-11):

- Tumulus:
  - Design 1 - On-grade reinforced concrete structural pad incorporating the following:
    1. RCRA-type closure cap with leachate collection and detection system (LCDS)
    2. RCRA-type impermeable liner underlayment
  - Design 2 - Compacted gravel structural pad incorporating the elements listed under Design 1 with the exception of the concrete pad, but including a 3-foot thick clay liner with a permeability of less than 1×10^{-7} cm/sec
- Aboveground Structure:
  - Design 1 - Vault constructed directly on-grade incorporating the following:
    1. Design 1A uses a liner system with LCDS
    2. Design 1B uses only a LCDS
  - Design 2 - Vault constructed with a structural support slab placed 6 feet above grade using an extended height reinforced concrete foundation incorporating the following:
    1. Design 2A uses a liner system with LCDS
    2. Design 2B uses only a LCDS

2.9 PACKAGING/TRANSPORTATION

The Department of Transportation (DOT) in Title 49 of the Code of Federal Regulations provides a number of general categories under which radioactive material may be shipped. Within the possible



NOTES:

1. SURFACE RUN-OFF FROM CAP AND DRAINAGE LAYER DISCHARGE WILL BE DIRECTED OFF-SITE FOR DISCHARGE TO LOCAL RECEIVER CREEK OR SEDIMENTATION BASIN

2. CAP THICKNESS WILL BE BASED ON 5 METER CRITERION PER 10CFR61

51

1804

408613-B-004
3-12-90 REV. 0

FIGURE 2-7. CAPPING PROFILE

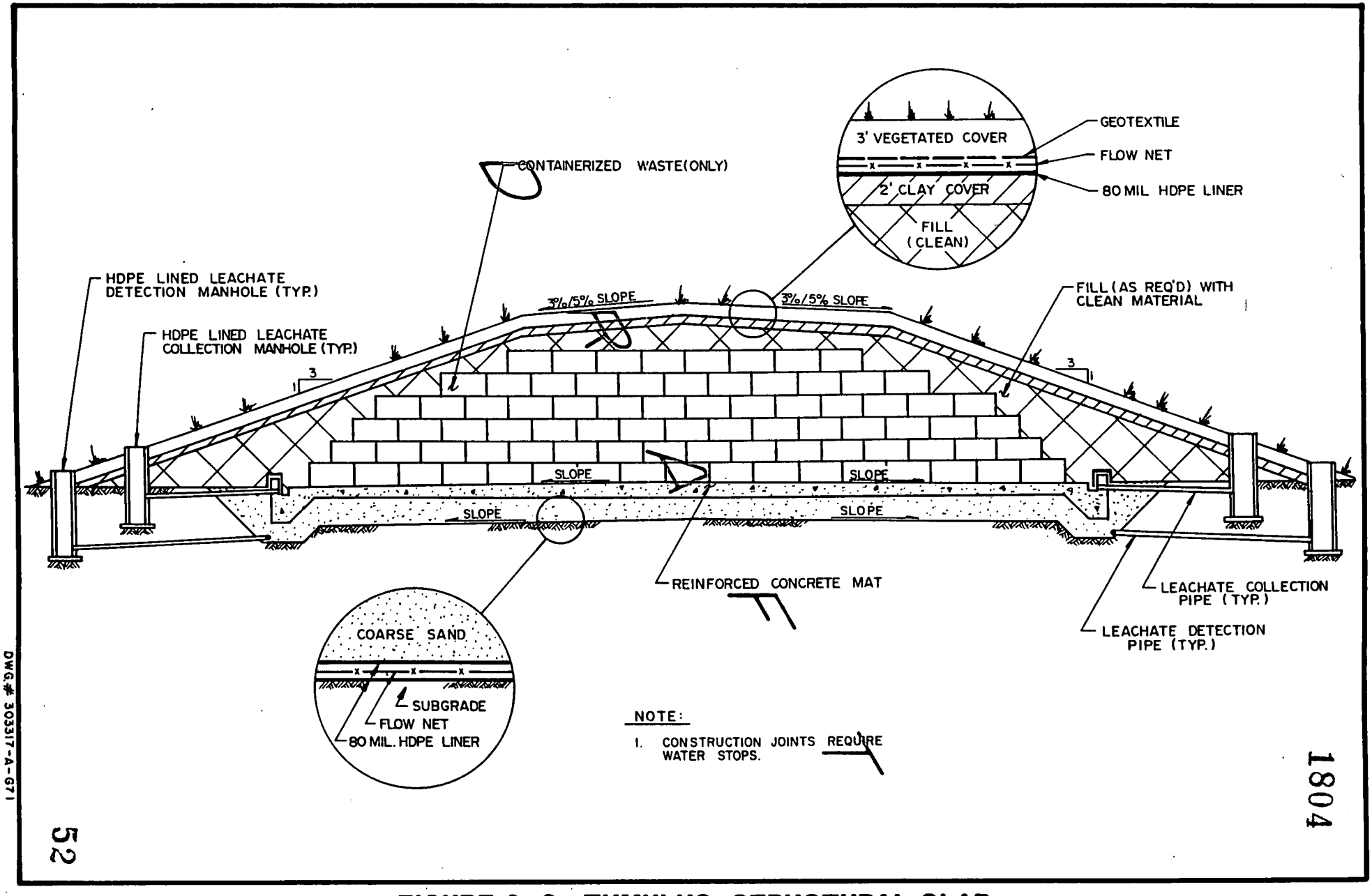


FIGURE 2-8. TUMULUS-STRUCTURAL SLAB

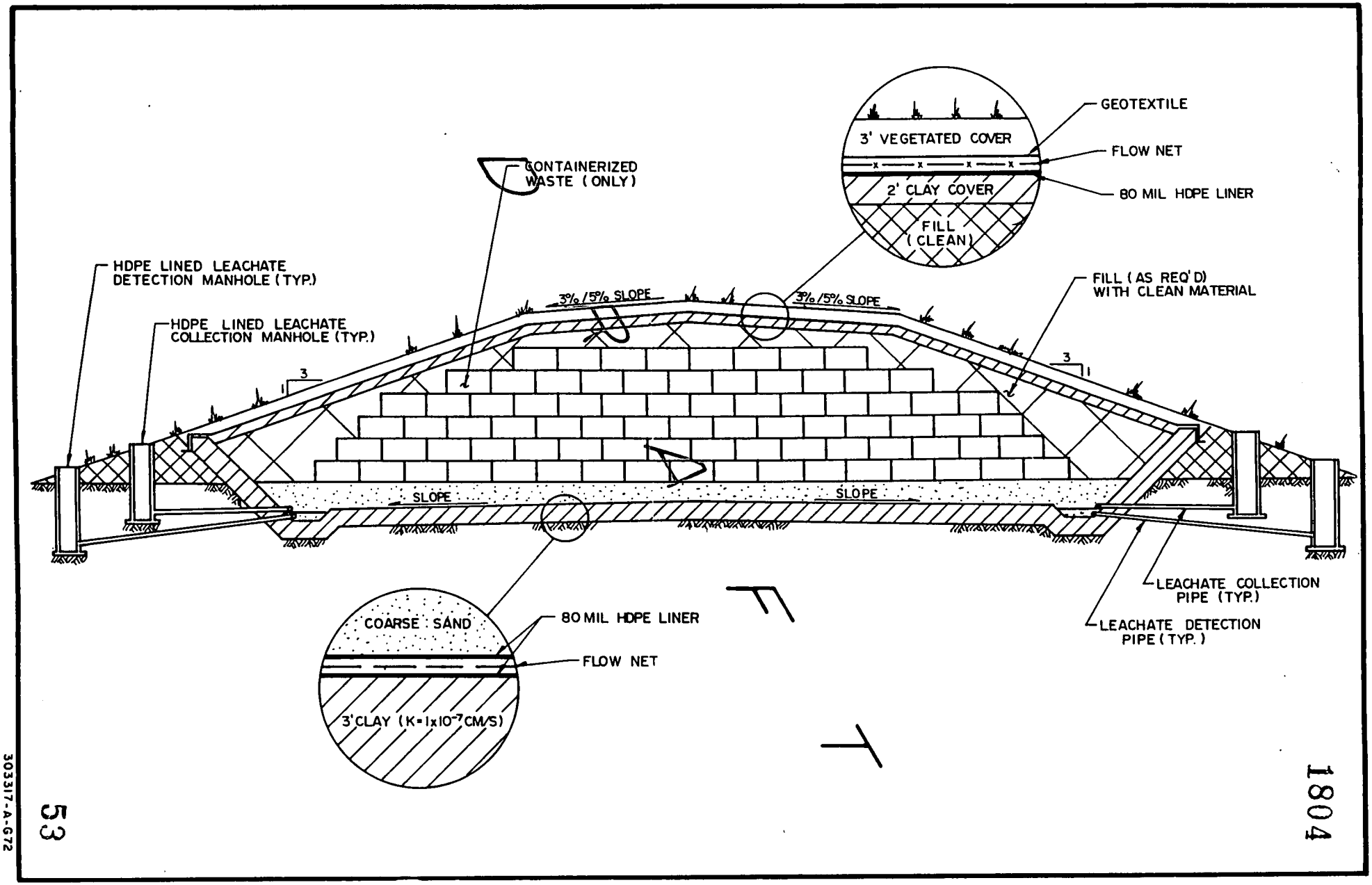


FIGURE 2-9. TUMULUS-COMPACTED COARSE SAND BASE

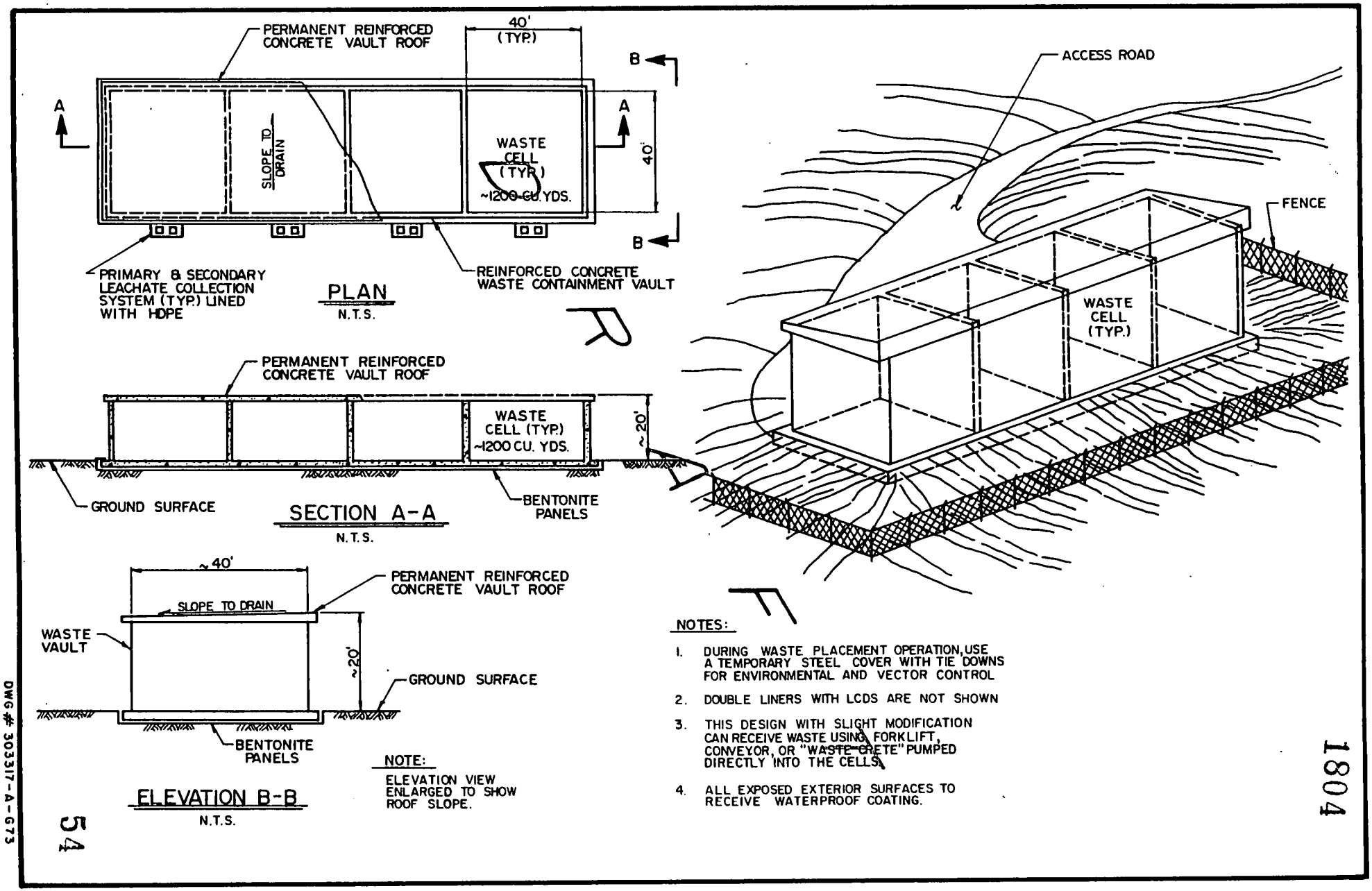


FIGURE 2-10. GREATER CONFINEMENT DISPOSAL VAULT FACILITY (GCD)

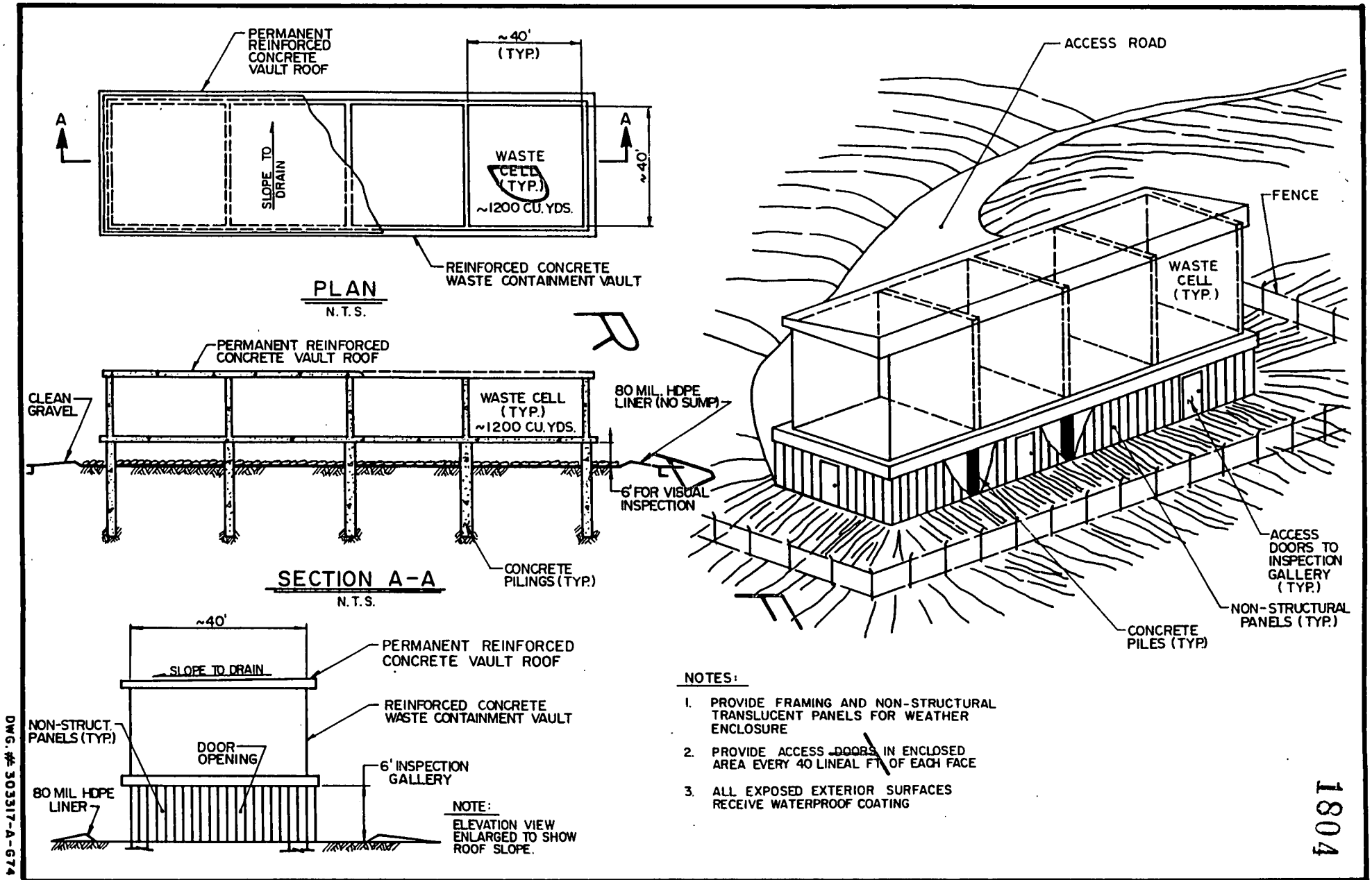


FIGURE 2-11. GCD WITH STRUCTURAL SLAB AND VAULT PLACED ABOVE GRADE

shipping designations allowed in the DOT regulations, there are four which apply to the K-65 and Silo 3 residues (with certain restrictions):

- Limited Quantities
- Low Specific Activity (LSA) material
- Type A package quantities
- Type B package quantities

Under each of these categories, the K-65 and Silo 3 residues will be specified as "normal form" because they have not been tested to meet the requirements of 49CFR173.469 (Tests for Special Form Radioactive Materials).

2.9.1 Limited Quantities

"Limited Quantities" of radioactive material is a designation for shipping the least restricted articles and the smallest quantities of radioactive material. Generally, items such as radioactive watches, clocks, and fire alarms are shipped under this category. Although the K-65 and Silo 3 residues could be made to conform to the restrictions of this classification, it would not be practical. This classification places a restriction on the activity level allowed in each shipping container and, due to the relatively high level of radioactivity found in the waste, it will require well over a billion packages to ship the waste. The logistics of inventorying and accounting for this number of packages alone renders this shipping classification unsuitable for the shipping of the silo waste.

2.9.2 LSA

The advantage to shipping radioactive material as LSA is to gain exemptions from using specification packaging (i.e., Type A, Type B, etc.). Whereas the other packaging and shipping classifications place a limit on the curie content of a package, the LSA classification places a limit on the specific activity of each package.

There are several subparts to the definition of LSA material, two of which may apply to the silo waste. The waste material may meet the definition of 49CFR173.403(n)(1) (Definitions) as "Uranium or thorium ores and physical or chemical concentrates of those ores." However, if it is decided that these residues are not ores or ore concentrates, they must meet the restrictions of 49CFR173.403(n)(4) (Definitions) which states: "Material in which the radioactivity is essentially uniformly distributed and in which the average concentration of the contents does not exceed:

(i) 0.0001 millicuries per gram of radionuclides for which the A_2 quantity is not more than 0.05 curie;
(ii) 0.005 millicuries per gram of radionuclides for which the A_2 quantity is more than 0.05 curie, but not more than 1 curie; or

(iii) 0.3 millicuries per gram of radionuclides for which the A_2 quantity is more than 1 curie."

(Note: A_2 is the maximum activity of normal form radioactive material permitted in a Type A package.)

In order to apply this second definition, it must be noted that 49CFR173.433(b)(3) (Requirements for Determination of A_1 and A_2 Values for Radionuclides) states that "In the case of a mixture of different radionuclides, where the identity and activity of each radionuclide is known, the permissible activity of each radionuclide R_1, R_2, ... R_n must be such that $F_1 + F_2 + ... F_n$ is not greater than unity, when:

$$F_1 = \frac{\text{Total activity of } R_1}{A_i(R_1)}$$

$$F_2 = \frac{\text{Total activity of } R_2}{A_i(R_2)}$$

$$F_n = \frac{\text{Total activity of } R_n}{A_i(R_n)}$$

Where $A_i(R_2, R_2, ... R_n)$ is the value of A_1 or A_2 as appropriate for nuclide R_1, R_2, ... R_n."

(Note: A_1 is the maximum activity of special form radioactive material permitted in a Type A package.)

What all of the foregoing means for Operable Unit 4 is that the radionuclides in the decay chain present in the silos will have to be divided into three categories: those with an A_2 value equal to or less than 0.05 curies, those with an A_2 value greater than 0.05 but not more than 1 curie, and those with an A_2 value greater than 1 curie. Based on present information, the radionuclides in all three of the silos are from the U-238 decay chain and fall into the categories just mentioned.

2.9.3 Type A

The silo residues can be shipped in Type A packaging which requires that the activity level in each package not exceed the A_2 value for the radionuclide of concern. 49CFR173.411 (General Design Requirements) and .412 (Additional Design Requirements for Type A Packages) list the design and performance specifications for Type A packaging. Type A packages are designed to more stringent

requirements than LSA packages and are typically used for the packaging of materials with greater levels of radioactivity. Type A containers are generally more expensive than LSA containers.

Due to the activity levels of the silo residues and the package activity level restrictions for Type A packages, the silo waste is estimated to require more than one million packages. As in the Limited Quantities discussion, the logistics for storing and accounting for this large quantity of packages would be prohibitive.

2.9.4 Type B

Type B packaging is required for all waste which exceed Type A packaging requirements. 49CFR173.411 (General Design Requirements) and 10CFR71.51 (Additional Requirements for Type B Packages) list the design and performance requirements for Type B packages. Type B packaging is constructed to much higher standards than either Type A or LSA packaging and is therefore much more expensive.

Generally, shipments of Type B quantities are made in a primary disposable container that is placed in a Type B overpack for transportation purposes only. The main advantages to Type B shipments are the use of larger packaging and less risk during shipment due to the higher grade packaging. The main disadvantages are cost, increased number of truck trips, and obtaining Type B overpacks. The silo waste can be shipped in Type B containers.

3.0

3.0 DEVELOPMENT OF ALTERNATIVES

3.1 SUMMARY

In accordance with the FMPC RI/FS Work Plan (Revision 3), several interim reports or presentations corresponding to distinct FS tasks were assigned as milestone deliverables. The Development of Alternatives report represented the initial step in the remedial action decision process. It was completed for all operable units at the FMPC in November, 1988.

The goal of this initial task was to develop and retain appropriate remedial actions for the alternative screening process. This was achieved for Operable Unit 4 by forming a complete set of response actions consistent with the applicable remedial action objectives. A universe of technology groupings was then identified and combined around these general response actions. This process evaluated the various technologies in terms of their implementability and their ability to meet the remedial action objectives. Those that did not satisfy these general criteria were eliminated from further consideration. The elimination of a given technology in this task necessarily dropped from consideration any process option that would have relied on that technology.

3.1.1 Remedial Action Objectives

Operable Unit 4 is an active source of radon contamination to the atmosphere and represents a potential source of contamination to groundwater and other environmental media; therefore, the remedial action objectives were centered on source control rather than pathway elimination or receptor modification. The remedial action objectives applicable to the silos of Operable Unit 4 were formulated to achieve the overall goal of protecting human health and the environment by isolating, removing, or treating the source of contamination.

The remedial action objectives identified for Operable Unit 4 at the time of alternative development are the following:

- Control and reduce the release of radon gas from the waste
- Control the migration of contaminants to environmental media that would exceed public health or environmental standards
- Control direct contact with contaminated structures
- Correct structural conditions that could lead to the sudden release of chemicals or radionuclides.

The remedial action objectives were kept general and do not specify the acceptable levels for the contaminants of concern for all pathways and receptors since they are objectives, not action levels

or goals. The primary reason for this was that all of the alternatives being considered for Operable Unit 4 (with the exception of the no-action alternative) would achieve the required protection of human health and the environment.

3.1.2 General Response Actions

General response actions are broad categories of remediation activities that will satisfy one or more of the remedial action objectives. These response actions include the no-action alternative, waste nonremoval actions, and waste removal actions.

The waste nonremoval actions for Operable Unit 4 encompass in situ stabilization and containment, and the waste removal actions involve various combinations of removal technologies, postremoval actions, and waste disposal options. For clarification, a postremoval action is an action occurring after removal (in this case treatment). A treatment action can be either in situ (preremoval) or ex situ (postremoval). Postremoval is intended to indicate an after removal action. The postremoval actions include waste vitrification, waste solidification, and contaminant separation. The disposal options include an on-site tumulus or above-grade vault or an off-site RCRA permitted disposal facility [in accordance with applicable regulations, including land disposal restrictions (LDR)].

3.1.3 Current Status

During the course of the refinement of alternatives as part of the screening of alternatives being reported herein, several assumptions made during the development of alternatives were reconsidered. Originally it was thought that the nonremoval and silo isolation alternative for the K-65 silos would not provide adequate public health or environmental protection and did not warrant further consideration. It was subsequently determined that the remedial action objectives may be met through the use of slurry walls and impermeable capping. The nonremoval and silo isolation alternative was therefore reinstated for further consideration in the alternative screening process. In addition, the vacuum removal of the K-65 waste was not originally considered, but is now being evaluated as a viable removal technology for several alternatives, as described in a later chapter.

The thorium inventory on site was considered under Operable Unit 4 at the time of alternative development; two of the remedial action alternatives focused on this thorium inventory. However, because the thorium is being appropriately managed under an ongoing FMPC operations program, the inventory is no longer part of Operable Unit 4 and the two related remedial action alternatives are no longer being considered. This reduces the number of Operable Unit 4 remedial action alternatives to 10, including the no-action alternative.

With the exception of the aforementioned, the assumptions and scope of the remedial action alternatives presented in this report are consistent with those in the Development of Alternatives Report.

3.2 SUMMARY OF ALTERNATIVES

In addition to the no-action alternative, nine distinct remedial action alternatives have been developed for Operable Unit 4. One reason for the relatively large number of alternatives is the significant differences in the material properties of the K-65 silos and Silo 3. Because of these differences, Alternatives 3 through 9 address only the K-65 silos or Silo 3. It should be noted that Alternatives 0 through 2, which address all of the silos, should be compared to Alternatives 3 through 5 combined with an Alternative from 6 through 9. There are two waste nonremoval and four waste removal alternatives for the K-65 silos, and there are three nonremoval and two removal alternatives for Silo 3. These alternatives are briefly described in Table 3-1 and in the following sections.

3.2.1 Alternative 0 - No Action

The no-action alternative provides no remediation and simply leaves the silos and silo waste in their present state. It includes the installation of long term monitoring equipment and silo maintenance. It provides a baseline against which the other alternatives can be compared.

3.2.2 Alternative 1 - Nonremoval, Silo Isolation - Silos 1, 2, 3

This nonremoval alternative for both the K-65 silos and Silo 3 consists of supplementing the existing containment of the silos with additional structural barriers and utilizing them as permanent disposal facilities. These barriers include an impermeable clay cap and slurry walls as considered technologies for this alternative.

3.2.3 Alternative 2 - Nonremoval, In Situ Stabilization, and Cap - Silos 1, 2, 3

This nonremoval alternative for all silos consists of in situ stabilization and capping. Both conventional physical stabilization technologies and vitrification are considered options. The capping and isolation technologies, with the exception of the slurry wall, are identical to those described in Alternative 1.

TABLE 3-1
REMEDIAL ACTION ALTERNATIVES

Alternative	0	1	2	3	4	5	6	7	8	9
Features	No Action	Isolation, Silos 1,2,3	In Situ Stabilization Silos 1,2,3	Removal, On-Site Disp. Silo 3	Removal, Off-Site Disp. Silo 3	Silo Rehab. Silo 3	Removal, Treatment, On-Site Disp. Silos 1,2	Removal, Treatment, Off-Site Disp. Silos 1,2	Removal, Contaminant Separation, On-Site Disp. Silos 1,2	Removal, Contaminant Separation, Off-Site Disp. Silos 1,2
Monitoring	X	X	X	X		X	X		X	
Maintenance	X	X	X	X		X	X		X	
Nonremoval	X	X	X			X				
Removal				X	X		X	X	X	X
Exterior Grouting		X	X							
Slurry Wall		X	X							
Impermeable Cap		X	X							
In Situ Stabil./Vitrif.			X							
Ex Situ Stabil./Vitrif.							X	X	X	X
Contaminant Separation									X	X
On-Site Disposal		X	X	X		X	X		X	
Off-Site Disposal					X			X		X

3.2.4 Alternative 3 - Removal and On-Site Disposal - Silo 3

This removal alternative for Silo 3 calls for pneumatic waste removal, with disposal in an engineered on-site disposal facility without interim treatment or stabilization. This also includes silo demolition and disposal of the debris.

3.2.5 Alternative 4 - Removal of Metal Oxides and Off-Site Disposal - Silo 3

This alternative for Silo 3 is identical to Alternative 3 with the exception of off-site waste shipment and disposal.

3.2.6 Alternative 5 - Removal and Replacement in Rehabilitated Silo - Silo 3

This alternative is similar to Alternative 3 with the exception of the final disposal scenario. In this case, the waste will be permanently stored in either Silo 3 or Silo 4 following its rehabilitation. Following final disposition of the waste, a berm and a cap will be installed.

3.2.7 Alternative 6 - Removal, Treatment, and On-Site Disposal - K-65 Silos

This removal alternative for the K-65 silos calls for the removal and conventional stabilization or vitrification of the waste prior to on-site disposal in an engineered disposal facility. This also includes silo demolition and disposal of the debris.

3.2.8 Alternative 7 - Removal, Treatment, and Off-Site Disposal - K-65 Silos

This alternative for removal of the K-65 waste is identical to Alternative 6 with the exception of off-site waste shipment and disposal.

3.2.9 Alternative 8 - Removal, Contaminant Separation, and On-Site Disposal - K-65 Silos

This removal alternative for the K-65 waste is similar to Alternative 6, but adds an additional step of contaminant separation to remove various radionuclides and metals before on-site disposal. This results in significant volume reduction and allows for the possible recovery of precious metals. The material containing the radionuclides and metals (the hazardous material stream) shall be solidified by conventional physical stabilization or vitrification prior to on-site disposal. This alternative also includes silo demolition and disposal of the debris.

3.2.10 Alternative 9 - Removal, Contaminant Separation, and Off-Site Disposal - K-65 Silos

This alternative is identical to Alternative 8, with the exception of off-site waste shipment and disposal.

4.0

4.0 ALTERNATIVE SCREENING METHODOLOGY

4.1 INTRODUCTION

Operable Unit 4 remedial action alternatives developed in the previous task had been assembled by combining process options from viable technologies in an attempt to meet the established remedial action objectives. Those technologies deemed not applicable or infeasible were eliminated. The resultant alternatives were based primarily on remedial action objectives and implementability concerns. There were few details identified at this stage for the individual process options and sizing requirements; remediation time frames were not fully characterized. It is the intent of the alternative screening to characterize these parameters more fully, to refine the alternatives accordingly, and to conduct the screening of alternatives by comparatively evaluating them on the basis of effectiveness, implementability and cost in accordance with the NCP at 40CFR300.430(e & f) (Remedial Investigation/Feasibility Study and Selection of Remedy).

This section will review the alternative screening requirements outlined in OSWER Directive 9355.3-1, briefly discuss Applicable or Relevant and Appropriate Requirements (ARARs), and introduce waste disposal considerations and their influence on the alternative ranking process.

4.2 REFINEMENT OF ALTERNATIVES

The following parameters were developed for each alternative:

- Remediation time frame and treatment rate (process throughput, i.e., pound/hour)
- Size, configuration, and availability of on-site extraction and treatment systems
- Physical area required for containment structures and support areas
- Packaging and transportation requirements for disposal options
- Permits and regulatory conditions and limitations of both on- and off-site disposal options

The remediation time frame is dependent on the size and configuration of the alternatives. These factors were considered in the preliminary design of each alternative, based on best engineering judgement. Two or more options were selected for some alternatives to maintain a variety of sizes and/or configurations.

Previously developed alternatives were modified if there were concerns about implementability or feasibility of the original concept. These modifications included changes to system configurations, implementation strategies, and the addition of treatment or containment technologies. Those alternatives which could not be modified to reduce or eliminate these concerns were eliminated

from further analysis, as were those judged to be similar but significantly inferior to other alternatives.

4.3 ALTERNATIVE EVALUATION PROCESS

The refined alternatives were evaluated against three broad criteria: effectiveness (short and long term), implementability, and cost. Because the purpose of this evaluation was to reduce the number of alternatives that undergo a more thorough and extensive analysis, alternatives were evaluated more generally in this phase than they will be during the subsequent detailed analysis task. The detailed analysis will subject the remaining alternatives to nine specific criteria and their individual factors rather than the three general criteria used in the alternative screening process. The individuals conducting the alternative screening reviewed the nine criteria to better understand the direction and intent of the detailed analysis. The relationship between the screening criteria and the nine criteria for the detailed analysis is illustrated in 4-1.

To ensure confidence in the results of the alternative screening process, two independent evaluations of the defined alternatives were completed. Per OSWER Directive 9355.3-1, the first evaluation made direct qualitative comparisons between similar alternatives for each of the general evaluation criteria. This identified the most promising alternatives in each grouping (i.e., on-site disposal alternatives, removal alternatives, etc.). The second evaluation, though relying on the same inputs as the first evaluation, generated a quantitative ranking of the alternatives. During this ranking, the alternatives were individually evaluated and assigned a relative rating value for each of the same evaluation criteria. The values were used to determine an overall ranking for comparison across alternatives. Although each evaluation approached the alternative screening process differently, the results of each were identical in terms of which alternatives should be retained for detailed analysis in the next Feasibility Study task.

Section 5.0 of this report discusses the anticipated performance of the alternatives in relation to each of the evaluation criteria. A standard rating terminology is used (i.e., poor, below average, average, above average, and good) to ensure a more uniform and consistent performance evaluation. These terms are used in a relative sense, i.e., a rating of average in a particular category means that an alternative is average relative to all of the alternatives considered. Section 6.0 of this report presents the results of the quantitative evaluation and those alternatives to be carried forward to the detailed analysis of alternatives.

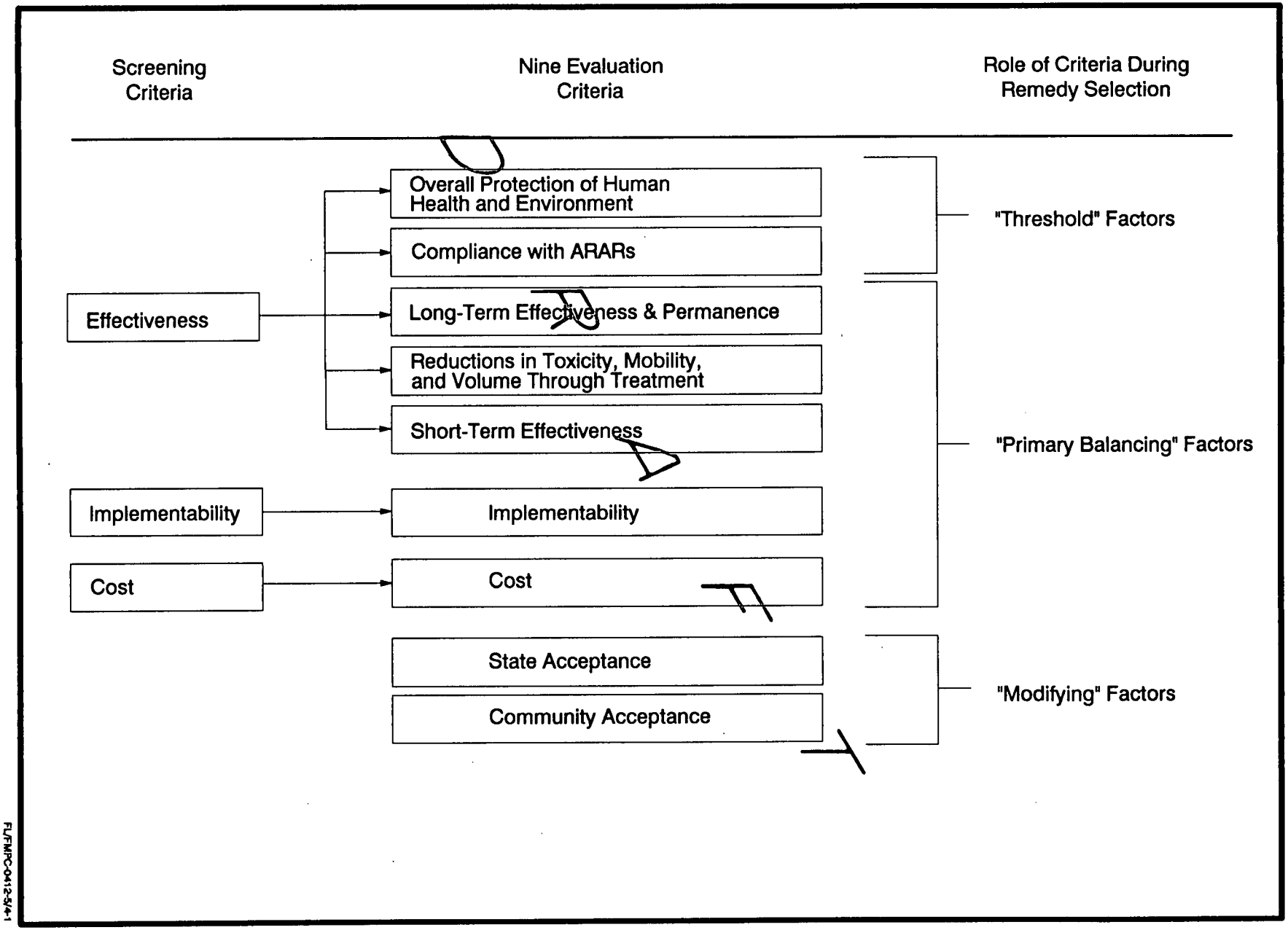


FIGURE 4-1. RELATIONSHIP OF SCREENING CRITERIA TO THE NINE EVALUATION CRITERIA

1804 DRAFT

4.3.1 Effectiveness Evaluation

A key aspect of the screening evaluation is the effectiveness of an alternative in protecting human health and the environment in accordance with the NCP at 40CFR300.430(e)(7)(i) (Remedial Investigation/Feasibility Study and Selection of Remedy)(Effectiveness). In addition to determining the effectiveness of the alternative in meeting the remedial action objectives, each alternative was evaluated as to its effectiveness in achieving reductions in toxicity, mobility and volume through treatment. Both short- and long-term effectiveness were evaluated, with the short-term referring to the construction and implementation period and the long-term referring to the post-remediation period.

4.3.2 Implementability and Reliability Evaluation

Implementability is a measure of both the technical and administrative feasibility of constructing, operating, and maintaining the components of a remedial action alternative in accordance with the NCP at 40CFR300.430(e)(7)(ii) (Remedial Investigation/Feasibility Study and Selection of Remedy)(Implementability). It provides a means of evaluating the compatibility of an alternative with site-specific conditions.

The technical feasibility evaluation considered the following:

- Construction
- Operation
- Regulations
- Maintenance
- Monitoring
- Material/equipment replacement
- Ongoing treatment and/or monitoring
- Discharge/emission/disposal

The administrative feasibility evaluation considered the following:

- Permitting and licensing approval
- Availability of on-site/off-site treatment, storage, and disposal services
- Availability of equipment
- Availability of design, operating, and support personnel

The reliability of each alternative was also evaluated in terms of the effects and impacts of possible downtime and/or process upsets on the performance of each alternative.

4.3.3 Cost Evaluation

Cost estimates were prepared for each alternative to allow a comparison of costs among similar alternatives in accordance with the NCP at 40CFR300.430(e)(7)(iii) (Remedial Investigation/Feasibility Study and Selection of Remedy)(Cost). This effort provided for the identification of alternatives that would cost substantially more than a similar alternative but would not provide a commensurate increase in protection of public health or environmental protection. These costs are rough estimates for comparison purposes only, and are not to be construed as construction/remediation estimates. The data uncertainties associated with the silo, berm, and subsoil contaminants, at this stage of the RI/FS for Operable Unit 4, forced these estimates to be very approximate. Cost estimates for items common to all alternatives or indirect costs (engineering, financial, supervision, and outside contractor support) were not detailed in the estimates.

The cost estimates are based on a variety of cost-estimating data such as cost curves, generic unit costs, vendor information, conventional cost-estimating guides, commercial remedial costs, and prior similar estimates as modified by site-specific information.

Capital costs are considered during this screening of alternatives. Included are those costs associated with waste packaging, off-site waste transportation, and disposal. The only operation and maintenance (O&M) costs considered are those associated with tumulus maintenance over a 30-year period. Other O&M costs either could not be determined or were judged to be negligible when compared to the capital costs. Potential future remedial action costs were not considered, as future remediation efforts are not currently defined.

4.3.4 Innovative Technologies

Technologies are classified as innovative if they are fully developed but lack sufficient cost or performance data for routine use at CERCLA sites. The nature of innovative technologies is such that a relatively complete performance and cost evaluation is not possible at this time due to insufficient data. Nevertheless, these technologies were carried through the screening phase if there was reason to believe that they offered the potential for comparable or superior impacts than other available approaches or if they offered the potential for lower costs for similar tests of performance than demonstrated treatment technologies in accordance with the NCP at 40CFR300.430 (Remedial Investigation/Feasibility Study and Selection of Remedy).

4.4 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

CERCLA requires that remedial actions achieve a level or standard of control which is applicable or relevant and appropriate to any hazardous substances, pollutants, or contaminants that will remain on site. Three classifications of ARARs are considered; 1) contaminant-specific, 2) location-specific, and 3) action-specific. Contaminant-specific ARARs address the acceptable amount or concentration of a specific pollutant that may be found in or discharged to soil, water, and air. Location-specific ARARs are based on the specific setting and nature of the site, and action-specific ARARs relate to technology or activity-based requirements or limitations on the specific response actions taken with respect to the type of waste. Thus, the determination of the potential ARARs for proposed actions at a site is based on factors specific to that site and the individual action; that is, on the nature of the contamination, the location of the site, and the general scope of the identified remedial action alternatives.

4.5 WASTE DISPOSAL CONSIDERATIONS

Evaluating the off-site versus on-site disposal issue for the silo waste is a complex process involving many subjectively evaluated criteria. Much of the data required to make a technical decision have not been obtained, and the detailed analysis of alternatives has not been performed. In an effort to provide additional insight, this issue was evaluated against much of the same criteria used to evaluate the alternatives. The advantages and disadvantages of each option are examined and briefly discussed in the sections that follow. These considerations shaped much of the alternative evaluations and played an important role in the overall ranking of alternatives. LDR impacts on disposal alternatives are discussed in this section.

4.5.1 Long-Term Effectiveness

Long-term effectiveness is defined as the effectiveness of an alternative in meeting the remedial action objectives during that period following remediation. Task 13 will provide additional information on this topic. For cost estimating purposes, CERCLA defines this period as 30 years. There are advantages to the off-site disposal options for long-term effectiveness. The disposal site used for cost estimation is the Nevada Test Site (NTS). A western site such as NTS is superior to Fernald in terms of demographics, meteorology, hydrology, and security. Additionally, long-term management, monitoring, and maintenance are already committed regardless of the presence of the silo waste. Whereas the silo waste will be an inconsequential part of the total waste buried at a western site, they will constitute a significant portion of the total radioactivity at Fernald should they remain on site.

4.5.2 Short-Term Effectiveness

In terms of short-term effectiveness, there are advantages to all on-site disposal options, especially the no-action and nonremoval options. These options result in a significantly reduced exposure and risk potential to workers and the public alike during the remediation operation, when compared to those options that require removal, treatment, and/or off-site disposal. Off-site disposal will expose both communities and the environment to transportation-related risks.

Disposal pretreatment processes for on-site or off-site disposal alternatives will factor heavily in determining the short-term effectiveness of a disposal option. This is because the treatment processes will require the waste to be exposed to workers, the public, and the environment for a greater period of time. Should an on-site disposal alternative require greater treatment than an off-site disposal option, all other points being equal, the short-term effectiveness ranking of the on-site disposal option will be less.

4.5.3 Reduction in Toxicity, Mobility, and Volume through Treatment

At this screening stage, this criterion does not play an important role in the on- versus off-site question. Performance to this criterion is equally important to both on- and off-site disposal options.

4.5.4 Implementability

Technically, the easiest alternative to implement is the no-action alternative. As the technologies become more complex they will be more difficult to implement. If on-site disposal is allowed, an enhanced burial design may be required, as will some type of waste treatment. Both of these requirements add to the difficulty of implementation. If off-site disposal is chosen, the implementability is compounded by the handling of waste shipping containers and the coordination of truck or rail shipments.

Implementing an off-site disposal option may be much easier for the technical reasons just cited. Furthermore, public acceptance may be greater at an established site than at Fernald.

4.5.5 Cost

The lowest estimated cost options are the no-action and nonremoval alternatives. Should future remediation be required for the no-action or nonremoval alternatives, these alternatives may prove to

be very expensive. When comparing an on-site alternative requiring an enhanced burial facility to a similar off-site disposal option, the estimated costs for the latter are substantially lower.

When considering the O&M costs associated with maintaining the on-site disposal facility (100 years per 10CFR61, Licensing Requirements for Land Disposal of Radioactive Waste), the off-site disposal option is generally less expensive than its on-site counterpart. The annual maintenance and monitoring costs at most approved disposal sites are already committed and will not be significantly affected by the addition of the silo waste. The annual O&M costs to maintain a disposal facility at Fernald, however, will be greater than for off site.

4.5.6 Overall Protection of Human Health and the Environment

The on-site disposal option may require a superior treatment process and a disposal facility with multiple and redundant containment features to match the protection provided by established burial grounds. Transportation of the silo waste to an off-site disposal area, however, presents a risk that must also be considered. Shipment of the waste by truck is currently being evaluated, though the number of shipments and the associated risk could be reduced if the shipments were made by rail. For example, if a railroad spur to a western site could be constructed for this purpose, it could be used by other federal facilities in the future.

4.5.7 Land Disposal Restrictions

LDR regulations will be complied with regarding on- or off-site disposal. Prior to disposal of any LDR waste treatment (contaminant separation, solidification, and/or vitrification) is required so that the waste form will pass toxicity characteristic leaching procedure (TCLP) or best demonstrated available treatment (BDAT) standards.

5.0

5.0 SCREENING OF ALTERNATIVES

The alternatives will be further refined and evaluated per the methodology defined in Section 3.0 of this report. These refined alternatives incorporate the technologies discussed in Section 2.0. The results of the alternative evaluation will be used to conduct the ranking of alternatives in Section 6.0. For the evaluation performed in this section, the alternatives were formally ranked according to their ability to meet the general screening criteria. The following numerical scale was used to rate the alternatives:

- 1=Poor
- 2=Below Average
- 3=Average
- 4=Above Average
- 5=Good

5.1 ALTERNATIVE 0 - NO ACTION

This alternative is the no-action alternative.

5.1.1 Description

In this alternative the silo waste remains unchanged without the implementation of any removal, treatment, containment, or mitigating technologies. Other than the installation of monitoring equipment and silo and berm maintenance, no actions are taken in this alternative.

5.1.1.1 System Requirements

This alternative requires:

- Groundwater monitoring stations
- Air monitors for radioactivity
- Area radiation monitors
- Silo and berm maintenance system

5.1.1.2 Size and Configuration

No change in the present site characteristics would be made.

5.1.1.3 Remediation Time Frame

No remediation as such would occur. The necessary monitoring equipment could be installed within 6 months.

5.1.1.4 Spatial Requirements

No additional space would be needed. The space taken by monitoring equipment could be within the existing silo area and could be insignificant.

5.1.1.5 Packaging Requirements

None required.

5.1.1.6 Waste Generated

No new waste would be generated.

5.1.1.7 Permits Required

None required.

5.1.2 Effectiveness

5.1.2.1 Protection of Human Health

Short- and long-term protection of public health would be poor because an unmitigated source of radioactive contamination would continue to exist in a structure that is in poor physical condition.

5.1.2.2 Protection of the Environment

Short- and long-term protection of the environment would be poor for the reasons cited above.

5.1.2.3 Reduction in Toxicity, Mobility, and Volume through Treatment

No reduction in any of these characteristics would occur in this alternative, therefore it is rated poor.

5.1.3 Implementability

5.1.3.1 Constructability

This alternative rates good in this category because no significant changes would be made and the installation of monitoring equipment would be routine.

5.1.3.2 Reliability

This alternative is below average in reliability. Although the minor work of monitor installation could be done with complete reliability, the silo structures themselves have a limited and poorly defined life expectancy.

5.1.3.3 Maintenance/Operation

This alternative is good from the standpoint of maintenance because little effort would be required to maintain the monitors, silos, and berms.

5.1.3.4 Agency Approvals

This alternative is rated very poor by this criterion because no remediation or mitigation would be carried out.

5.1.3.5 Special Engineering and Equipment

The alternative is rated good because all aspects of the work to be done would be routine.

5.1.4 Cost

No costs are associated with the silo facilities themselves. The required monitoring equipment and maintenance could involve up to $1 million.

5.1.5 Additional Data Needs

None required.

5.1.6 Screening Summary

Because very little would be changed on the site location, this alternative is very constructable and easy to maintain, with no needs for special engineering and equipment. However, it rates very low in all of the remaining criteria. It fails to meet waste treatment or effective long-term disposal solutions and remedial actions.

Initially, this alternative has the lowest estimated cost, but the short-term savings would be lost if long-term operational, maintenance, and future remediation costs are considered.

The overall level of human health and environmental protection provided by this alternative is extremely low, as increased radon releases and contaminant migration are certain to occur without some sort of remedial action. This, coupled with the proximity of the waste to the Great Miami

Aquifer and a major population center (Cincinnati, Ohio), makes a recommendation of this alternative unlikely.

5.2 ALTERNATIVE 1 - NONREMOVAL, SILO ISOLATION - SILOS 1, 2, 3

5.2.1 Description

This nonremoval alternative for the K-65 silos and Silo 3 provides for their use as permanent disposal facilities following the enhancement of the containment integrity of each silo. The technologies considered for remediation are:

- K-65 Silos:
  - Slurry wall around silos
  - Filling of silo void space
  - Impermeable cap
- Silo 3:
  - Extension of the berm to Silo 3 and utilization of the isolation techniques described for the K-65 silos.

The soil in the berm and under the K-65 silos may contain significant levels of Pb-210 and Po-210 from the decay of radon which has diffused into them. There are no data to confirm or refute this; on-going studies are addressing this issue. Until confirmed otherwise, the berm material is assumed not to be characteristically hazardous for its lead content. The slurry wall and cap would be designed to enclose any radioactively contaminated soil. The basis for this statement is that all contaminated material must be isolated or treated. The cap for the K-65 silos would extend to intersect a partial slurry wall and overlap the silo walls. It is assumed that general and granular fill, and a $1x10^{-7}$ cm/sec, clay borrow source with minimum horizontal permeability are regionally available.

5.2.1.1 System Requirements

This alternative requires:

- Impermeable clay cap and slurry wall
- Relocation of Paddys Run
- Long-term maintenance and environmental monitoring program
- Leachate collection system

5.2.1.2 Size and Configuration

The impermeable cap for all three silos would cover approximately eight acres.

5.2.1.3 Remediation Time Frame

Remediation would take approximately 1 year from the initial staging of construction equipment to final closure of the silos.

5.2.1.4 Spatial Requirements

A staging area for the construction equipment would be the only requirement.

5.2.1.5 Packaging Requirements

None required.

5.2.1.6 Waste Generated

Leachate will be generated due to K-65 silo waste subsidence caused by the added weight of the installed impermeable cap. This would be collected in the existing leachate collection system and processed by the FMPC wastewater treatment system.

5.2.1.7 Permits Required

The relocation of Paddys Run would require compliance with substantive conditions of the Army Corps of Engineers permit program.

5.2.2 Effectiveness

5.2.2.1 Protection of Human Health

The short-term effectiveness is good because there would be no waste handling activities and, therefore, none of the associated risks.

It is possible that with dedicated extended maintenance and monitoring, the long-term effectiveness could be maintained even though the waste had not been treated. However, the alternative remains poor in this category because it is uncertain whether the containment techniques utilized would prevent contaminant migration over the long term. Modeling data and current contamination levels for the areas under the silos are not available and will impact the design of the containment technology.

5.2.2.2 Protection of the Environment

The short- and long-term effectiveness is good and poor, respectively, for the reasons stated in the previous section.

5.2.2.3 Reduction in Toxicity, Mobility, and Volume through Treatment

This alternative rates average in this category because, although the containment provided would reduce the mobility of the contaminants for the short term, there would be no reduction in toxicity or volume (except through subsidence/consolidation).

5.2.3 Implementability

5.2.3.1 Constructability

This alternative rates good in this category because the technology is available and proven.

5.2.3.2 Reliability

The reliability of the operations making up this alternative is above average.

5.2.3.3 Maintenance/Operation

Maintenance and monitoring would be required to ensure that the remedial action objectives continue to be met. This alternative rates average in this category.

5.2.3.4 Agency Approvals

Agency approval for on-site disposal of untreated waste may prove to be more difficult to obtain than for removal and/or treatment alternatives. This alternative rates below average in this category.

5.2.3.5 Special Engineering and Equipment

This alternative requires no special engineering, equipment, or technical expertise and is rated good in this category.

5.2.4 Cost

The cost estimate for this alternative is $13 million.

5.2.5 Additional Data Needs

In accordance with the OSWER Directive 9355.3-1, as previously discussed, additional sampling is required to determine the extent of soil and water contamination, the behavior of contaminant migration, and the physical properties of the soil. This applies to all subsequent alternatives.

5.2.6 Screening Summary

The chief advantages of this alternative are its relatively simple and low cost for implementation and its effective short-term protection of human health and the environment.

The primary disadvantages of this alternative are that it fails to reduce waste toxicity and volume as a containment-only alternative. The requirement for future remediation is a distinct possibility. Current regulatory preferences list waste treatment and effective long-term disposal solutions as desirable remedial actions.

5.3 ALTERNATIVE 2 - NONREMOVAL, IN SITU STABILIZATION, AND CAP - SILOS 1, 2, 3

5.3.1 Description

This nonremoval alternative for the K-65 silos and Silo 3 provides for the stabilization and isolation of the waste. In situ chemical stabilization or vitrification would be utilized in addition to capping and slurry walls. At this stage, vitrification is included as an innovative technology. The cap required for this alternative would be identical to that described for Alternative 1.

Because the treatment of the waste would require that the silos be open to the atmosphere, an EIE would be necessary for containment and protection of public health.

Following the installation of the EIE, the silo domes would be removed and the waste stabilized. The cap design will be dependent on the stabilization process used: vitrified waste would require a cap only to control erosion, whereas chemically stabilized waste may require a cap to reduce leaching. A slurry wall may be installed in the berm surrounding the silos to provide an additional barrier to prevent contaminant migration. During the vitrification process, the silo walls would be vitrified along with parts of the berm.

5.3.1.1 System Requirements

This alternative requires:

- EIE
- Earth moving equipment
- Stabilization equipment (conventional or vitrification)
- 4-8 MW electrical power supply for the vitrification process
- Miscellaneous utilities
- Long-term maintenance and environmental monitoring program

5.3.1.2 Size and Configuration

Conventional physical stabilization requires an auger and mixers and vitrification requires melters, fume hoods, and an APC system. Either of these stabilization technologies requires support facilities.

5.3.1.3 Remediation Time Frame

The remediation of all three silos based on stabilization would take approximately two to three years from the initial pilot-scale study and site work to final capping. The additional time requirement, if any, for ISV is uncertain at this stage due to the unknown schedule for full-scale testing. The pilot-scale study would be necessary to determine the voltages, intrusion depth, and other technical criteria for the vitrification process.

5.3.1.4 Spatial Requirements

The spatial requirements are:

• EIE (Silos 1 and 2)	36,400 sq ft
• EIE (Silo 3)	19,600 sq ft
• Area for support equipment and facilities	16,000 sq ft
• Staging area for capping material	30,000 sq ft

5.3.1.5 Packaging Requirements

None required.

5.3.1.6 Waste Generated

The following waste would be generated:

- Contaminated steam, volatile metals and fumes, and contaminated dust from vitrification process
- Water from dehumidification of EIE air
- Compactable, low-level waste (anti-contamination clothing, gloves, HEPA filters, etc.)
- Any equipment too contaminated to warrant decontamination

5.3.1.7 Permits Required

Should it be necessary to discharge to the air or water, substantive conditions of the existing National Emission Standards for Hazardous Air Pollutants (NESHAP) or National Pollutant Discharge Elimination System (NPDES) permits would be complied with. The relocation of Paddys Run would require compliance with substantive conditions of the Army Corps of Engineers permit program.

5.3.2 Effectiveness

5.3.2.1 Protection of Human Health

The short-term effectiveness is average, in that no waste would be removed and there would be no risk of a waste handling accident. The use of the EIE greatly reduces the chance for accidental public exposure during remediation.

The long-term effectiveness evaluation of this alternative must take into account the fact that the waste would be permanently located over the Great Miami Aquifer and near a major population center (Cincinnati, Ohio). Although the long-term stability of the immobilized waste is quite good, the long-term effectiveness of this alternative is judged to be average.

5.3.2.2 Protection of the Environment

The short-term effectiveness is average for the reasons stated in the previous section.

The long-term effectiveness is above average because the waste mobility reduction and the impermeable cap would greatly reduce the migration of contaminants to the air or groundwater.

5.3.2.3 Reduction in Toxicity, Mobility, and Volume through Treatment

Although the volume of the silo waste would not be affected by this alternative (the volume of the final waste form might increase or decrease, dependent on the stabilization technology employed), the mobility and toxic characteristics of the waste would be greatly reduced by the isolation and immobilization technologies employed. This alternative is judged to be above average in this category.

5.3.3 Implementability

5.3.3.1 Constructability

The silo isolation and chemical stabilization technologies are proven and known to be effective; however, complete in situ vitrification at the depths required for this application has never been demonstrated. Substantial development and demonstration work will be required to adequately determine the effectiveness of this process option. The constructability of this alternative is average.

5.3.3.2 Reliability

The reliability of this alternative's processes is average for chemical stabilization and below average for vitrification. This evaluation for ISV is based on the lack of full-scale testing and proven demonstration to the depths required for the silos.

5.3.3.3 Maintenance/Operations

Perpetual maintenance and monitoring would be required to ensure that the remedial action objectives continue to be met. This alternative rates average in this category.

5.3.3.4 Agency Approvals

Agency approval for on-site disposal of untreated waste may prove to be more difficult to obtain than for removal and/or treatment alternatives. This alternative rates below average in this category.

5.3.3.5 Special Engineering and Equipment

The isolation and chemical stabilization technologies identified for this alternative are proven and the required equipment is readily available; however, not for the depths required. Both the in situ vitrification option and the chemical stabilization option would require substantial testing and development. This alternative rates poor in this category.

5.3.4 Cost

The estimated cost for the vitrification option is $24 million, and for the chemical stabilization option is $19 million.

5.3.5 Additional Data Needs

Prior to the selection of the vitrification option, a substantial amount of testing and development would be required to validate the process. Treatability studies as well as depth testing would also be required to confirm and refine the conventional stabilization option.

5.3.6 Screening Summary

The primary disadvantages of this alternative are the questionable effectiveness of the vitrification technology at the depths required, and the associated schedule delays and higher estimated cost. As previously stated, appreciable testing and development would be required with no guarantee of success. The use of conventional stabilization technologies is more likely to be effective in completely stabilizing the waste; however, treatability testing would still be required prior to full endorsement of this technology.

For a nonremoval alternative, with its immobilization and isolation of the waste, this alternative does provide above average long-term public health and environmental protection. However, perpetual maintenance and monitoring coupled with the possibility of future remediation makes this alternative one of the least favorable.

5.4 ALTERNATIVE 3 - REMOVAL AND ON-SITE DISPOSAL - SILO 3

5.4.1 Description

This removal alternative for the remediation of the Silo 3 waste provides for waste removal, silo demolition, and disposal of both the waste and silo debris in an engineered on-site disposal facility. The waste would be pneumatically removed from the silo and packaged for on-site disposal without interim treatment or stabilization (Figure 5-1). The hydraulic method is described in Section 2.0, as are the designs for the engineered on-site disposal facility.

An EIE would be necessary because each of the removal methods require the removal of the silo dome. To implement any of these methods, it would be necessary to construct a work platform to gain accessibility to the silo dome and contents.

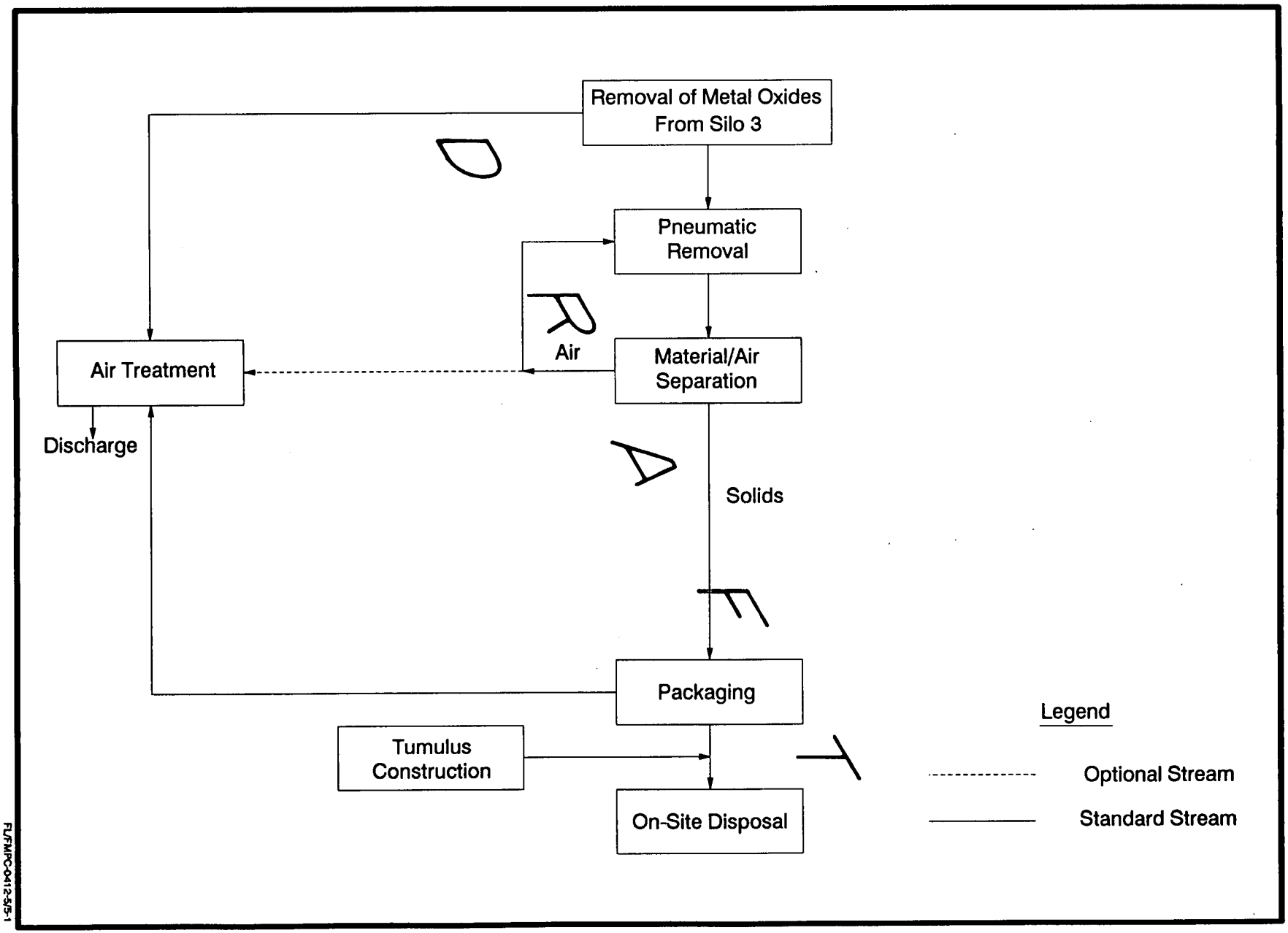


FIGURE 5-1. ALTERNATIVE 3 - REMOVAL AND ON-SITE DISPOSAL - SILO 3

FL/FMPC-0412-5/5-1

1804 DRAFT

5.4.1.1 System Requirements

This alternative requires:

- EIE
- Waste removal equipment
- For vacuum removal- an air supply and an air treatment system
- Packaging method
- On-site storage facility
- Miscellaneous utilities
- Long-term maintenance and environmental monitoring program

5.4.1.2 Size and Configuration

The selected method of material removal will have a bearing on the size and configuration of the equipment installed. Waste characterization is not yet complete and the results of scheduled sampling activities will have an effect on the material handling, packaging, and air treatment systems designs. Each of the removal methods described in Section 2.0 would be designed to handle 1 to 5 cubic feet of material per minute.

5.4.1.3 Remediation Time Frame

Remediation would take approximately 2 years from installation of the EIE to decontamination and disassembly of process equipment.

5.4.1.4 Spatial Requirements

The spatial requirements are:

• EIE (140 ft x 140 ft)	19,600 sq ft
• Process/packaging area (100 ft x 100 ft)	10,000 sq ft
• Tumulus or equivalent	12 acres

The size of the tumulus is based on the estimated waste volume and design specific parameters.

5.4.1.5 Packaging Requirements

The packaging of the waste material for on-site disposal would be performed in an enclosed facility to prevent accidental release of radioactive material to the environment. Good engineering practices emphasizing compatibility between the container and material, as well as package retrievability, would be followed when choosing a container.

5.4.1.6 Waste Generated

The following waste would be generated:

- Water from dehumidification of EIE air
- Compactable, low-level waste (anti-contamination clothing, gloves, HEPA filters, etc.)
- Any equipment too contaminated to warrant decontamination

5.4.1.7 Permits Required

Should it be necessary to discharge to the air or water, substantive conditions of the existing NESHAP or NPDES permits would be complied with.

5.4.2 Effectiveness

5.4.2.1 Protection of Human Health

The short-term effectiveness is above average. Although this waste removal action would involve the risk of a waste handling accident during removal, packaging, or transport to the on-site disposal facility, the waste, in their present state, are relatively stable and of low radiological activity.

The long-term effectiveness is average because the waste may not be stabilized and would be located over the Great Miami Aquifer near a major population center (Cincinnati, Ohio).

5.4.2.2 Protection of the Environment

The short- and long-term effectiveness is above average and average, respectively, for the reasons stated in the previous section.

5.4.2.3 Reduction in Toxicity, Mobility, and Volume through Treatment

This alternative is average. Although the waste would be reasonably stable and immobile in the disposal facility, their toxicity and volume would not be reduced.

5.4.3 Implementability

5.4.3.1 Constructability

The removal methods and the on-site disposal facility being considered are based on available and proven technologies. This alternative rates average in this category.

5.4.3.2 Reliability

The reliability of this alternative is good.

5.4.3.3 Maintenance/Operation

Perpetual maintenance and monitoring would be required to ensure that the remedial action objectives continue to be met. This alternative is rated average in this category.

5.4.3.4 Agency Approvals

Agency approval for the on-site disposal of untreated waste would prove to be difficult, however, since agency preference is for treatment alternatives. This alternative is rated below average in this category.

5.4.3.5 Special Engineering and Equipment

This alternative does not require any skills or equipment that are not presently available, although the removal equipment may require minor modification. This alternative rates average in this category.

5.4.4 Cost

The estimated cost for this alternative is $49 million.

5.4.5 Additional Data Needs

The results of the silo sampling effort are required to better determine the specific requirements.

5.4.6 Screening Summary

This alternative is quite good in providing short-term public health and environmental protection and employs reliable remediation technologies at a moderate estimated cost. The long-term effectiveness from a health and environmental standpoint is average, however, as untreated waste would still be present on site over the Great Miami Aquifer.

5.5 ALTERNATIVE 4 - REMOVAL AND OFF-SITE DISPOSAL - SILO 3

5.5.1 Description

This removal alternative for the remediation of the Silo 3 waste is identical to Alternative 3 with the exception of the final disposal of the waste. This alternative calls for the off-site disposal of the untreated waste and silo debris, thereby precluding the need for an on-site disposal facility.

The additional requirement to be met for this alternative involves transportation to an approved off-site disposal facility (Figure 5-2).

5.5.1.1 System Requirements

This alternative requires:

- EIE
- Waste removal equipment
- For vacuum removal- an air supply and an air treatment system
- Miscellaneous utilities
- Packaging and shipping method
- Approved off-site disposal facility

5.5.1.2 Size and Configuration

The selected method of material removal will have a bearing on the size and configuration of the equipment installed. Waste characterization is not yet complete and the results of scheduled sampling activities will have an effect on the material handling, packaging, and air treatment systems designs. Each of the removal methods described in Section 2.0 would be designed to handle 1 to 5 cubic feet of material per minute.

5.5.1.3 Remediation Time Frame

Remediation would take approximately 2 years from installation of the EIE to decontamination and disassembly of process equipment.

5.5.1.4 Spatial Requirements

The spatial requirements are:

• EIE (140 ft x 140 ft)	19,600 sq ft
• Process/packaging area (100 ft x 100 ft)	10,000 sq ft

5.5.1.5 Packaging/Transportation Requirements

The packaging options available for the Silo 3 waste are low specific activity (LSA) containers and Type B containers. Type A quantities and limited quantities will not be considered for reasons previously stated (Section 9.3).

LSA

Due to the specific activity requirements for shipping LSA quantities, the Silo 3 waste would have to be blended with materials of a lesser specific activity. Operable unit boundaries could

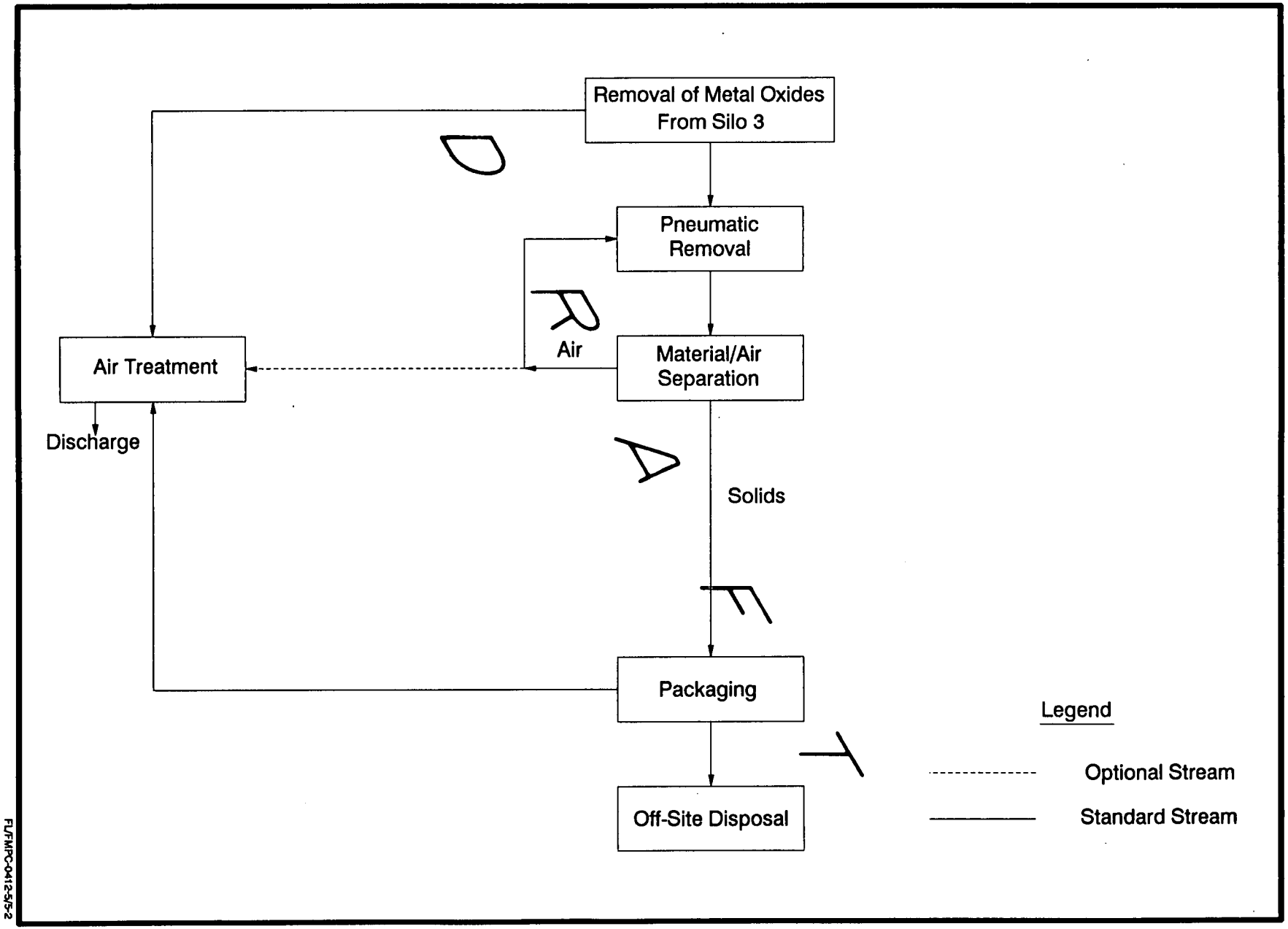


FIGURE 5-2. ALTERNATIVE 4 - REMOVAL AND OFF-SITE DISPOSAL - SILO 3

DRAFT

1804

be crossed to provide this additional material (e.g., fly ash). LSA boxes measuring 96 cubic feet could be used.

Type B

To ship the waste as Type B quantities would not require waste blending, as there are no activity limits for Type B packaging.

The waste would be placed in 55-gallon drums and placed in Type B overpacks.

The waste, regardless of the packaging option selected, would be transported by truck or train to an approved off-site disposal facility.

5.5.1.6 Waste Generated

The following waste will be generated:

- Water from dehumidification of EIE air
- Compactable, low-level waste (anti-contamination clothing, gloves, HEPA filters, etc.)
- Any equipment too contaminated to warrant decontamination

5.5.1.7 Permits Required

Should it be necessary to discharge to the air or water, substantive conditions of the existing NESHAP or NPDES permits would be complied with. Permits/licenses would be required to transport the waste to an approved off-site disposal facility.

5.5.2 Effectiveness

5.5.2.1 Protection of Human Health

The short-term effectiveness is average and rates lower than the previous alternative due to the inherent hazards associated with shipment of the waste to an off-site disposal facility.

The long-term effectiveness is above average and rates higher than the previous alternative as the waste would be better isolated from the public in a remote off-site disposal facility.

5.5.2.2 Protection of Environment

The short-term effectiveness is average and rates lower than the previous alternative for the reasons mentioned in the previous section.

The long-term effectiveness is above average and rates higher than the previous alternative as the waste are assumed to be stored in a remote facility that experiences very little precipitation and is geologically stable.

5.5.2.3 Reduction in Toxicity, Mobility, and Volume through Treatment

This alternative is average in this category. Although the waste would be reasonably stable and immobile in the disposal facility, their toxicity and volume would not be reduced.

5.5.3 Implementability

5.5.3.1 Constructability

With the exception that this alternative does not require the construction of an on-site disposal facility, the constructability of this alternative is identical to that of Alternative 3 and therefore rates average.

5.5.3.2 Reliability

Alternative 4 is judged to be less reliable than Alternative 3 (good) due to the transportation concerns. These concerns are that delays in completing the remedial alternative may be encountered in preparing for and conducting waste shipments. Therefore, Alternative 4 rates above average.

5.5.3.3 Maintenance/Operation

This alternative is judged to be much better than Alternative 3 in this category because, being an off-site disposal alternative, there would be no local maintenance or operational requirements. This alternative rates good in this category.

5.5.3.4 Agency Approvals

This alternative is judged better than Alternative 3 because agency requirements are completely defined for off-site disposal. This alternative rates average in this category.

5.5.3.5 Special Engineering and Equipment

This alternative requires no additional skills and/or equipment beyond those identified in Alternative 3, with the possible exception of special packaging that may be required for shipment. This alternative rates average in this category.

5.5.4 Cost

The estimated cost for this alternative is $9 million if the waste is shipped as LSA material and $25 million if the waste is shipped as Type B material.

5.5.5 Additional Data Needs

The results of the silo sampling effort are required to better determine the specific requirements.

5.5.6 Screening Summary

The disadvantage of this alternative when compared to Alternative 3 is its greater short-term public health and environmental risk due to waste transportation. As an off-site disposal alternative, however, this alternative betters Alternative 3 when long-term effectiveness, maintenance, and operation requirements are considered.

Overall, this alternative is more favorable than Alternative 3 due to its superior long-term effectiveness.

5.6 ALTERNATIVE 5 - REMOVAL AND REPLACEMENT IN REHABILITATED SILO - SILO 3

5.6.1 Description

This alternative is similar to Alternative 3 with the exception of the final disposal scenario. In this case, the waste would be permanently stored in either Silo 3 or Silo 4 following its rehabilitation. Following final disposition of the waste, a berm and a cap would be installed.

The removal techniques and the EIE used for this alternative are similar to those described for Alternative 3. Additional containment would be required around Silo 3. The cap and berm design would be similar to those described in Alternative 1.

5.6.1.1 System Requirements

This alternative requires:

- Pressure grouting and earth moving equipment
- Impermeable clay cap, slurry wall, and grout
- Relocation of Paddys Run
- Long-term maintenance and environmental monitoring program
- EIE
- Waste removal equipment
- For vacuum removal - an air supply and an air treatment system
- Waste transfer system
- Miscellaneous utilities

5.6.1.2 Size and Configuration

The impermeable cap for Silo 3 or Silo 4 would cover approximately three acres.

5.6.1.3 Remediation Time Frame

Remediation would take approximately 2 years from the initial staging of construction equipment to final closure of the silos.

5.6.1.4 Spatial Requirements

The spatial requirements are:

• EIE (140 ft x 140 ft)	19,600 sq ft
• Process area (100 ft x 100 ft)	10,000 sq ft

5.6.1.5 Packaging Requirements

No packaging would be involved in this option.

5.6.1.6 Waste Generated

The following waste would be generated:

- Water from dehumidification of EIE air
- Compactable, low-level waste (anti-contamination clothing, gloves, HEPA filters, etc.)
- Any equipment too contaminated to warrant decontamination

5.6.1.7 Permits Required

Should it be necessary to discharge to the air or water, substantive conditions of the existing NESHAP or NPDES permits will be complied with. The relocation of Paddy Run would require compliance with substantive conditions of the Army Corps of Engineers permit program.

5.6.2 Effectiveness

5.6.2.1 Protection of Human Health

The short-term effectiveness is below average for the Silo 3 rehabilitation because of the extensive waste handling required in moving the waste to and from Silo 4. The risk of a waste handling accident and subsequent exposure to the public is greatly increased by the repeated handling. For storage in a rehabilitated Silo 4, the short-term effectiveness is considered average due to the one-time handling of the Silo 3 material. Overall, short-term effectiveness is considered average for Alternative 5.

The long-term effectiveness is below average because the waste would not be physically stabilized and a rehabilitated silo cannot guarantee the long-term isolation of the contaminants.

5.6.2.2 Protection of the Environment

The short-term effectiveness of this alternative is below average for the Silo 3 rehabilitation because of the increased risk of a handling accident and subsequent contamination of the local environment. Also, for the same reason as discussed in Section 5.6.2.1, short-term effectiveness for the storage of the Silo 3 material in rehabilitated Silo 4 is considered average.

The long-term effectiveness is below average for the reasons stated in the previous section.

5.6.2.3 Reduction in Toxicity, Mobility, and Volume through Treatment

Although the waste would remain reasonably stable in their presently dry and powdery form, their toxicity and volume would not be reduced. This alternative rates average in this category.

5.6.3 Implementability

5.6.3.1 Constructability

This alternative rates below average in this regard due to the fact that the complete rehabilitation of a 35-year-old structure cannot be ensured.

5.6.3.2 Reliability

The reliability of this alternative rates below average because the long-term isolation of the waste in the rehabilitated silo cannot be ensured.

5.6.3.3 Maintenance/Operation

The rehabilitated silo would require perpetual monitoring and maintenance to ensure that the remedial action objectives are met over the long term. This alternative rates average in this category.

5.6.3.4 Agency Approvals

Agency approval for this alternative is unlikely, as this is a nontreatment, nonremoval action which would permanently store the waste in a facility of questionable structural integrity. This alternative rates poor in this category.

5.6.3.5 Special Engineering and Equipment

This alternative rates average in this category as there are no requirements for special engineering or equipment.

5.6.4 Cost

A cost estimate for this alternative has not been developed, since it is being eliminated from further consideration based on an inadequate degree of effectiveness and implementability.

5.6.5 Additional Data Needs

None required.

5.6.6 Screening Summary

This alternative rates poorly overall because of the on-site storage of the Silo 3 material in a structurally questionable facility. The result is a low level of public health and environmental protection for both the short- and long-term.

5.7 ALTERNATIVE 6 - REMOVAL, TREATMENT, AND ON-SITE DISPOSAL - K-65 SILOS

5.7.1 Description

This removal alternative for the remediation of the K-65 waste provides for waste removal, treatment, and on-site disposal in an engineered disposal facility. The waste would mechanically, pneumatically, or hydraulically removed from the silos and then chemically or physically stabilized before packaging and on-site disposal (Figure 5-3). The silos and berms would be demolished, decontaminated or treated (if necessary), packaged, and disposed of in the on-site disposal facility. The contaminated berm material may be disposed of as radioactive waste and the clean material may be used as fill material elsewhere.

The removal methods, related air and water treatment systems, EIE, and tumulus design for this alternative are similar (except for the differences in moisture content) to those for Alternative 3 and will not be discussed here. The two technologies considered for treatment are ex situ chemical stabilization and ex situ vitrification.

5.7.1.1 System Requirements

This alternative requires:

- EIE
- Waste removal equipment
- Stabilization equipment (conventional or vitrification)
- For hydraulic removal- a water supply system
- For vacuum removal- an air supply and an air treatment system
- Packaging method
- On-site storage facility
- Miscellaneous utilities
- Long-term maintenance and environmental monitoring program

5.7.1.2 Size and Configuration

The configuration, required equipment, and capacities for the removal methods are identical to those for Alternative 3 and will not be described here. The material handling, packaging, and treatment system designs are dependent on waste characterization which has not yet been completed.Conventional stabilization requires process equipment that includes driers, mixers, conveyors, and some type of automated packaging equipment. Vitrification requires specialized equipment such as a glass melter, fume hood/cap, and an air pollution control system. Either of these stabilization methods require support facilities separate from those supporting removal activities.

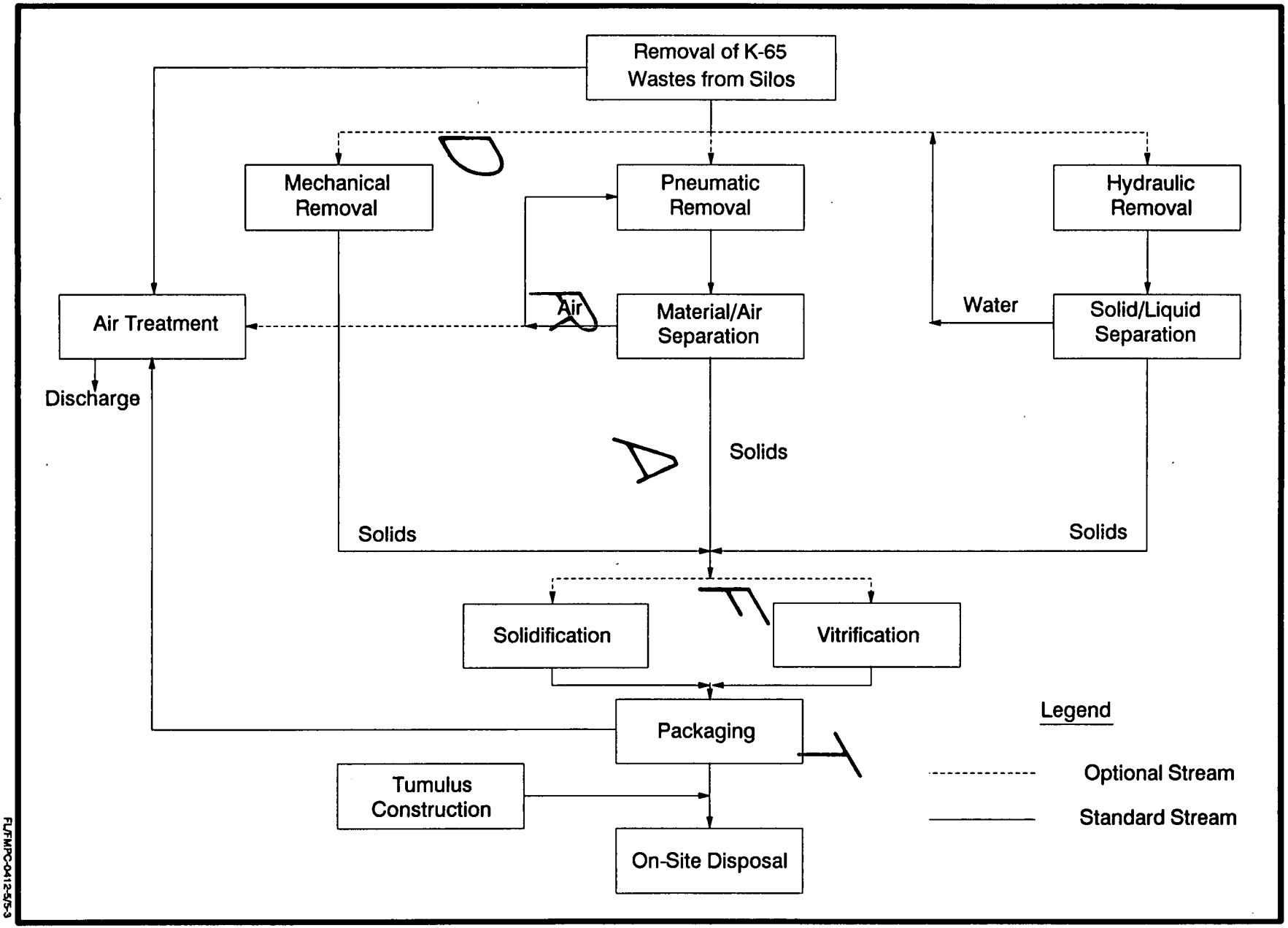


FIGURE 5-3. ALTERNATIVE 6 - REMOVAL, TREATMENT, ON-SITE DISPOSAL - SILOS 1, 2

FL/TM/PC-0412-5/5-3

1804 DRAFT

5.7.1.3 Remediation Time Frame

Installation of the EIE, including all removal, stabilization, and packaging equipment, would take approximately 5 months. Removal of the material processing and packaging would take an additional 18 months. Demolition and disassembly/demobilization would require approximately 6 months. During this time the on-site disposal facility would be built. The total remediation time for this alternative would be approximately 3 years.

5.7.1.4 Spatial Requirements

The spatial requirements are:

- EIE (260 ft x 140 ft) — 36,400 sq ft
- Process/packaging building (100 ft x 100 ft) adjacent to the EIE — 10,000 sq ft
- Tumulus or equivalent — 15 acres

The size of the tumulus is based on the estimated waste volume and design-specific parameters.

5.7.1.5 Packaging Requirements

The packaging of the waste material for on-site disposal would be performed in an enclosed facility to prevent accidental release of radioactive material to the environment. For cost estimating purposes an approved, LSA-type, steel container has been chosen.

5.7.1.6 Waste Generated

The following waste would be generated:

- Water from dehumidification of EIE air
- Compactable low-level waste (anti-contamination clothing, gloves, HEPA filters, etc.)
- Any equipment too contaminated to warrant decontamination

5.7.1.7 Permits Required

Should it be necessary to discharge to the air or water, substantive conditions of the NESHAP or NPDES permits would be complied with.

5.7.2 Effectiveness

5.7.2.1 Protection of Human Health

The short-term effectiveness is below average due to the risks associated with the extensive waste handling during removal, treatment, and movement.

The long-term effectiveness is below average because the waste would be disposed of near the Great Miami Aquifer. The question of ARARs is presently being investigated.

5.7.2.2 Protection of the Environment

The short-term effectiveness of this alternative is below average for the reason stated in the previous section.

The long-term effectiveness of this alternative is average because the waste mobility reduction and impermeable clay cap of the on-site tumulus would greatly reduce the potential for the migration of contaminants to the air or groundwater.

5.7.2.3 Reduction in Toxicity, Mobility and Volume through Treatment

Overall, this alternative is judged to be above average in this category due to the significant decrease in the mobility of the material provided by the stabilization/vitrification techniques used. Although the toxic content of the waste is not reduced, the toxicity characteristic is potentially greatly reduced. The volume of the disposed waste would increase if the stabilization option is selected.

5.7.3 Implementability

5.7.3.1 Constructability

Although the technologies presented are available and proven, the treatment processes may require special design and engineering. This alternative rates average in this category.

5.7.3.2 Reliability

The reliability of this alternative is judged to be good.

5.7.3.3 Maintenance/Operation

Perpetual maintenance and monitoring would be required to ensure that the on-site disposal facility continues to meet the remedial action objectives. This alternative is rated average in this category.

5.7.3.4 Agency Approvals

Agency approval to permanently store stabilized waste above the Great Miami Aquifer may prove to be difficult even though the waste have been treated. This alternative is rated below average in this category.

5.7.3.5 Special Engineering and Equipment

This alternative would require special design and engineering of the treatment processes and specialized handling and treatment equipment. The technology and equipment is generally available and proven so this alternative rates average in this category.

5.7.4 Cost

The estimated cost for this alternative is $65 million. Unlike Alternative 2, there is no significant economic difference between vitrification and stabilization. Vitrification equipment is more expensive than stabilization equipment; however, the difference is off-set because the tumulus required for the vitrified material is smaller than that for the stabilized material.

5.7.5 Additional Data Needs

Treatability studies would be required to determine process parameters and the effectiveness of the process options.

5.7.6 Screening Summary

The disadvantages of this alternative are its low level of short- and long-term public health and environmental protection. The short-term disadvantage is due to the substantial waste handling involved during remediation. Although the stabilizing technologies are very effective in immobilizing the waste, they would still be present on site and represent a long-term potential hazard to both the public and the environment.

5.8 ALTERNATIVE 7 - REMOVAL, TREATMENT, AND OFF-SITE DISPOSAL - K-65 SILOS

5.8.1 Description

This alternative is identical to Alternative 6 with the exception that the treated waste would be transported to an approved off-site disposal facility, thereby precluding the need for an on-site disposal facility. The additional requirements to be met for this alternative involve packaging and transportation for disposal (Figure 5-4). See the Alternative 6 description for details.

5.8.1.1 System Requirements

This alternative requires:

- EIE
- Waste removal equipment
- Stabilization equipment (conventional or vitrification)
- For hydraulic removal - a water supply system
- For vacuum removal - an air supply and an air treatment system
- Miscellaneous utilities
- Packaging and shipping method
- Approved off-site disposal facility

5.8.1.2 Size and Configuration

The configuration, required equipment, and capacities for the removal methods are identical to those for Alternative 3 and will not be described here. The material handling, packaging, and treatment system designs are dependent on waste characterization which has not yet been completed.

Conventional stabilization requires process equipment that includes driers, mixers, conveyors, and some type of automated packaging equipment. Vitrification requires specialized equipment such as a glass melter, fume hood/cap, and an air pollution control system. Either of these stabilization methods will require support facilities separate from those supporting removal activities.5.8.1.3

5.8.1.3 Remediation Time Frame

Installation of the EIE, including all removal, stabilization, and packaging equipment, would take approximately 5 months. Removal of the material, processing, and packaging would take an additional 18 months. Demolition and disassembly/demobilization would require approximately 6 months. The total remediation time for this alternative is approximately 3 years.

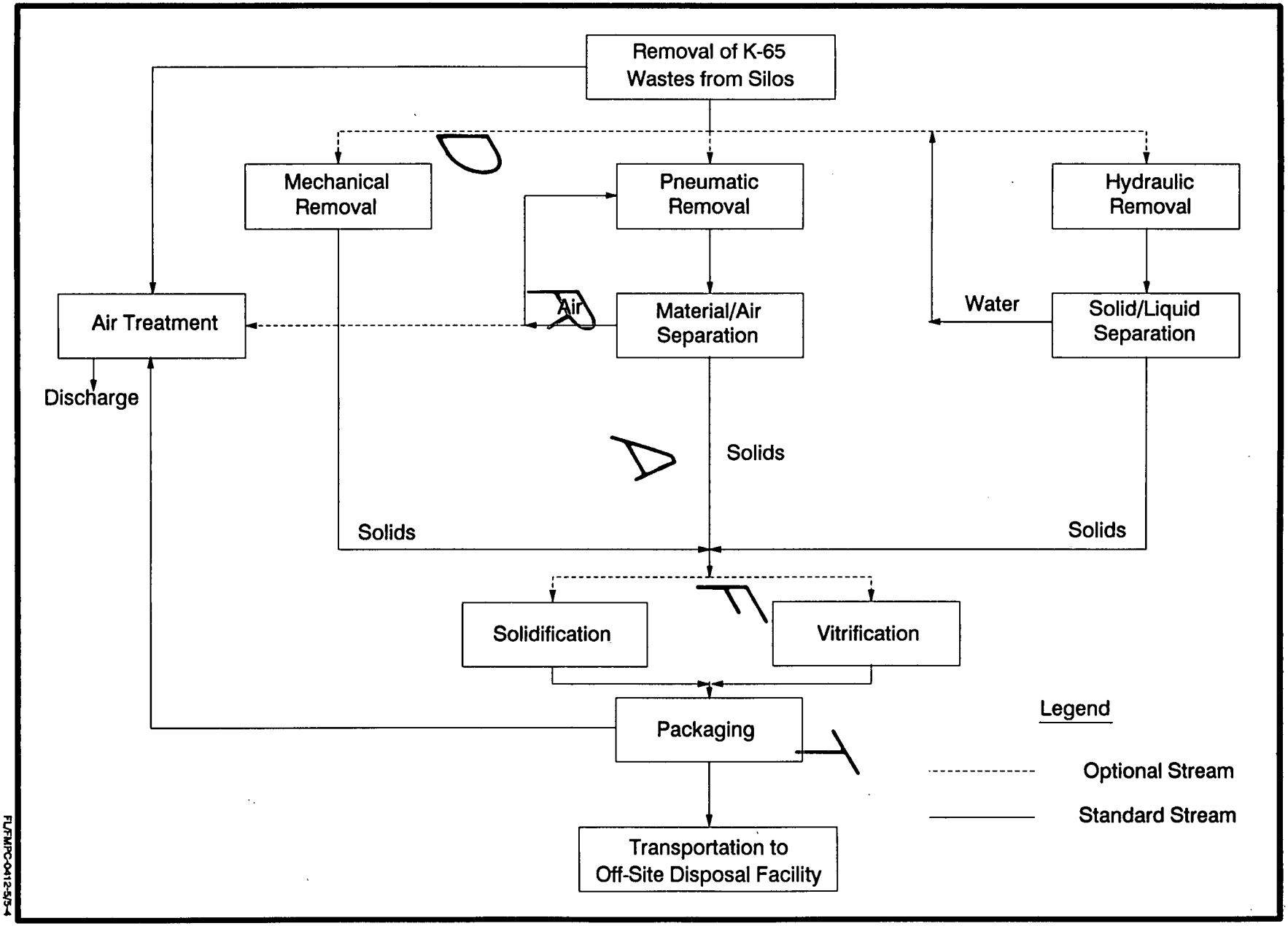


FIGURE 5-4. ALTERNATIVE 7 - REMOVAL, TREATMENT, OFF-SITE DISPOSAL - SILOS 1, 2

5.8.1.4 Spatial Requirements

The spatial requirements are:

• EIE (260 ft x 140 ft)	36,400 sq ft
• Process/packaging building (100 ft x 100 ft) adjacent to the EIE	10,000 sq ft

5.8.1.5 Packaging/Transportation Requirements

The packaging options available for the treated K-65 waste are LSA containers and Type B containers. Type A quantities and Limited Quantities will not be considered for the reasons previously stated.

LSA

To meet the LSA specific activity limits, the waste would have to be blended with material of a lesser activity. One choice for this is the silo berm material as it might be slightly contaminated requiring disposal. LSA boxes measuring 96 cubic feet could be used for this disposal option.

Type B

No waste blending would be required for shipment as a Type B quantity, as there are no activity limits for Type B packages. The waste material would be placed in 55-gallon drums and packed into Type B overpacks.

The waste, regardless of the packaging option selected, would be transported by truck or rail to an approved off-site disposal facility.

5.8.1.6 Waste Generated

The following waste would be generated:

- Water from dehumidification of EIE air
- Compactable low-level waste (anti-contamination clothing, gloves, HEPA filters, etc.)
- Any equipment too contaminated to warrant decontamination

5.8.1.7 Permits Required

Should it be necessary to discharge to the air or water, substantive conditions of the existing NESHAP or NPDES permits would be complied with. Permits/licenses would be required to transport the waste to an approved off-site disposal facility.

5.8.2 Effectiveness

5.8.2.1 Protection of Human Health

The short-term effectiveness of this alternative is below average due to the removal, treatment, and other miscellaneous waste handling operations that increase the risk of a handling accident and subsequent public exposure. Additional risk of public exposure would be incurred during waste transport to the off-site disposal facility.

Long-term effectiveness of this alternative is good due to the off-site disposal of the treated waste in a facility likely to be more geographically remote and environmentally suitable.

5.8.2.2 Protection of the Environment

The short-term effectiveness of this alternative is below average for the reasons stated in the previous section.

The long-term effectiveness of this alternative is good due to the off-site disposal of the treated waste in a geologically stable facility that experiences little precipitation.

5.8.2.3 Reduction in Toxicity, Mobility, and Volume through Treatment

The contaminants are immobilized by both conventional stabilization and vitrification, although no reduction in toxicity or volume is realized. Conventional stabilization will actually increase the volume of the disposed waste. This alternative is rated above average in this category.

5.8.3 Implementability

5.8.3.1 Constructability

This alternative is identical to Alternative 6 in this respect and rates average.

5.8.3.2 Reliability

This alternative is less reliable than Alternative 6 (good) due to the difficulties inherent in effecting the off-site disposal of the waste. This alternative rates above average in this category.

5.8.3.3 Maintenance/Operation

This alternative is significantly better than Alternative 6 because the waste would be stored off-site and will require no local operation and maintenance efforts. This alternative rates good in this category.

5.8.3.4 Agency Approvals

Although there will be numerous regulatory requirements to satisfy prior to shipping the radioactive waste, the waste would not be disposed of near the Great Miami Aquifer. This alternative rates average in this category.

5.8.3.5 Special Engineering and Equipment

This alternative is identical to Alternative 6 in this category and rates average.

5.8.4 Cost

The estimated cost for this alternative is $37 million if the waste is shipped as LSA material and $42 million if the waste is shipped as Type B material.

5.8.5 Additional Data Needs

Treatability studies would be required to determine the effectiveness of the process options and to determine process parameters.

5.8.6 Screening Summary

Due to the numerous waste handling steps required - removal, treatment, packaging, and long distance transportation to an off-site disposal facility - this alternative provides the lowest level of short-term public health and environmental protection. It also fails to reduce waste volume (which increases with conventional stabilization) and toxicity content. This alternative does, however, effectively immobilize the waste by stabilization/vitrification and this, combined with off-site disposal, provides one of the most effective long-term disposal options for the K-65 waste.

5.9 ALTERNATIVE 8 - REMOVAL, CONTAMINANT SEPARATION, AND ON-SITE DISPOSAL - K-65 SILOS

5.9.1 Description

This removal alternative calls for K-65 waste removal, separation of radioactive/hazardous components and nonhazardous components through various contaminant separation schemes, and

subsequent on-site disposal of the resultant waste. The waste would be removed by hydraulic or mechanical methods (Figure 5-5). These methods have been discussed previously and will not be covered here. This alternative would also require the use of an EIE.

Dependent on the removal method selected, the waste would be received either as a slurry (hydraulic removal) or a sludge (mechanical removal) via a conveyor. Before initial treatment the slurry may have to be dewatered. The conveyed sludge may be passed through a screen to ensure particle size is such that optimum leaching occurs. It is not anticipated that size reduction equipment will be required. Contaminant separation would begin with a multistage, nitric acid leach which would solubilize the uranium, radium, and lead, the major radionuclides of concern. This leaching process would also dissolve the barium, calcium, iron, nickel, and copper. The lead, barium, nickel, and copper are the primary hazardous constituents of the sludge. It may be necessary to add an oxidizing agent, as well as hydrochloric acid (which has been shown to improve leaching effectiveness), to assist in the solubilization of the uranium. Literature exists which states this process can be successful. Although the chemistry of these reactions is fairly well known, this leaching step would require laboratory bench-scale testing to determine the effectiveness of the leaching and the proper acid and sludge ratios.

After leaching, the mixture would be filtered and washed to remove the dissolved components from the remaining sludge. The filtrate, containing the hazardous and radioactive components, would be treated with sodium hydroxide, sodium carbonate, and/or sodium sulfate/phosphate to a pH of about 10.5 to precipitate the lead, barium, radium, uranium, nickel, and copper. This process would also precipitate calcium and some iron. The supernatant water may be recycled or require further treatment prior to discharge. The precipitated sludge would be solidified or vitrified as previously described.

If the initial leaching is sufficiently effective the remaining washed material may be considered nonhazardous, which would allow low-cost disposal in a nonhazardous landfill. As this material contains approximately $10,000,000 worth of precious metals (gold, platinum, and palladium), another option in lieu of disposal would be the recovery of these metals by smelting. Gold exists in the material at a ratio of 1.36 troy ounces per ton and is routinely recovered by commercial smelters from ores containing as little as 0.1 troy ounces per ton. The silos contain approximately 12,000 troy ounces of gold, 2,700 troy ounces of platinum, and 35,000 troy ounces of palladium. The material could be sold to a smelter for recovery, because an on-site smelting operation would not be cost effective due to the relatively small quantities involved.

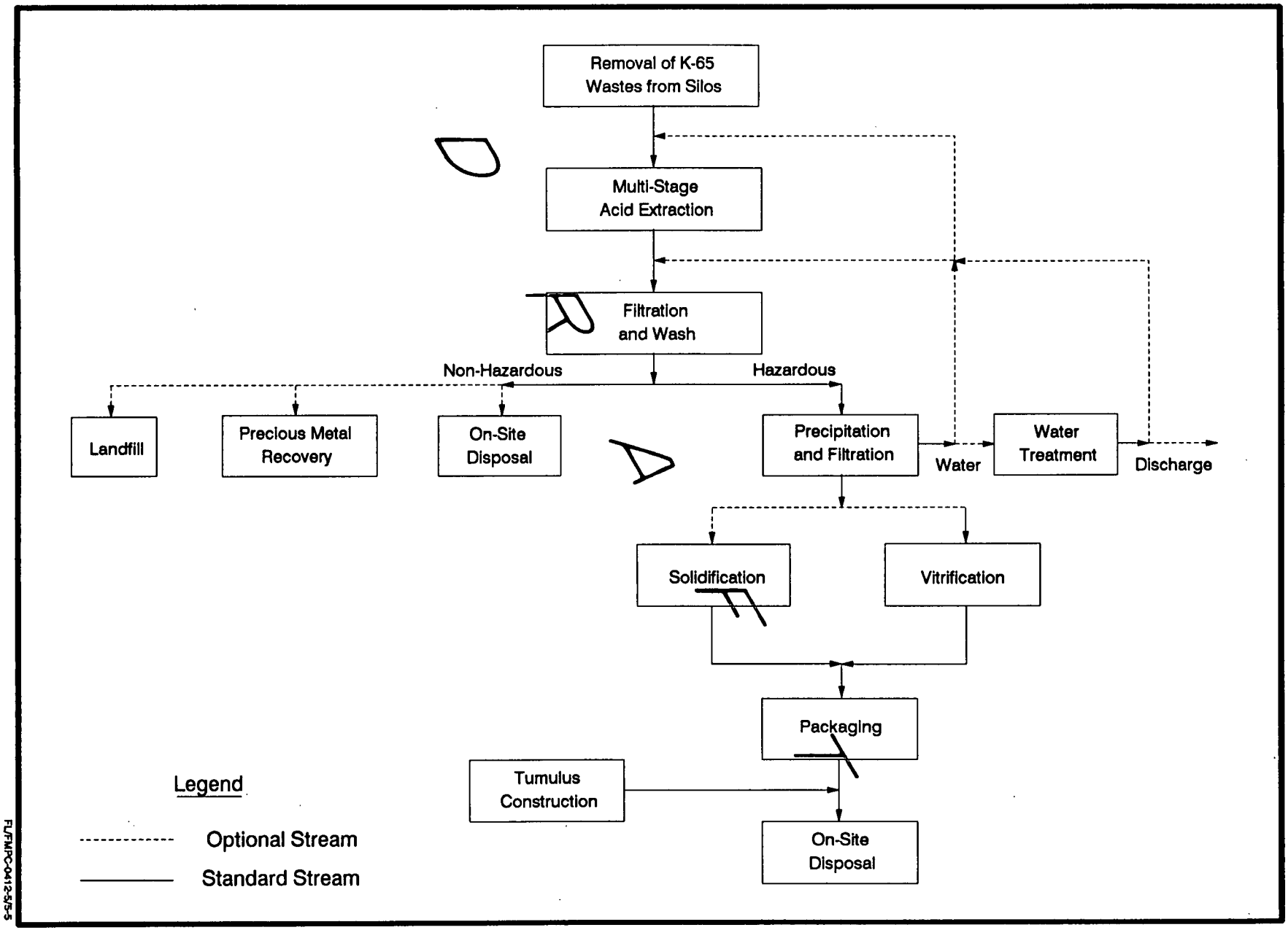


FIGURE 5-5. ALTERNATIVE 8 - REMOVAL, CONTAMINANT SEPARATION, ON-SITE DISPOSAL - SILOS 1, 2

FL/FMPC-0412-5/5-5

5.9.1.1 System Requirements

This alternative requires:

- EIE
- Miscellaneous utilities
- Tumulus or similar aboveground disposal facility
- Waste removal and handling equipment
- Waste treatment and contaminant separation equipment
- Packaging method
- Treatability testing for leaching and separation

5.9.1.2 Size and Configuration

The waste removal method and stabilization option selected would have a bearing on the size and configuration of the equipment installed. The configuration, required equipment, and capacities for the removal methods are identical to that for Alternative 3 and will not be described here.

Conventional stabilization requires process equipment that includes driers, mixers, conveyors, and some type of automated packaging equipment. Vitrification requires specialized equipment such as a glass melter, fume hood/cap, and an air pollution control system. Either of these stabilization methods require support facilities separate from those supporting removal activities.

The contaminant separation equipment would consist of a series of agitated batch tanks, precipitation tanks, and associated piping and hardware.

5.9.1.3 Remediation Time Frame

Installation of the EIE, including all of the removal, stabilization, contaminant separation, and packaging equipment, would take approximately 5 months. Removal of the material, treatment/separation, and packaging would take an additional 18 months. Demolition and disassembly/demobilization would require approximately 6 months. The total remediation time for this alternative is approximately 3 years.

5.9.1.4 Spatial Requirements

The spatial requirements are:

• EIE (260 ft x 140 ft)	36,400 sq ft
• Process/packaging building adjacent to EIE (120 ft x 120 ft)	14,400 sq ft
• Tumulus or equivalent	8 acres

5.9.1.5 Packaging Requirements

The packaging of the waste material for on-site disposal would be performed in an enclosed facility to prevent accidental release of radioactive material to the environment. Good engineering practices emphasizing compatibility between the container and material, as well as package retrievability, would be followed when choosing a container.

5.9.1.6 Waste Generated

The following waste would be generated:

- Wastewater from hydraulic removal method (recycled where possible)
- Water from dehumidification of EIE air
- Nitric acid waste stream to be treated in the on-site biodenitrification pond
- Compactable, low-level waste (anti-contamination clothing, gloves, HEPA filters, etc.)

5.9.1.7 Permits Required

Should it be necessary to discharge to the air or water, substantive conditions of the existing NESHAP or NPDES permits would be complied with.

5.9.2 Effectiveness

5.9.2.1 Protection of Human Health

The short-term effectiveness is average due to the waste handling involved during removal, treatment, contaminant separation, packaging, and disposal.

The long-term effectiveness is below average because although the waste has been treated, immobilized, reduced in volume, and placed in secure storage, the continued presence of these concentrated waste on site is a disadvantage.

5.9.2.2 Protection of the Environment

The short- and long-term effectiveness is average and below average, respectively, for the reasons stated in the previous section.

5.9.2.3 Reduction in Toxicity, Mobility, and Volume through Treatment

This alternative is good in this category because it very effectively reduces the volume and mobility through contaminant separation and stabilization/vitrification. The resultant radioactive waste, though greatly reduced in volume, would be more concentrated in its separated form.

5.9.3 Implementability

5.9.3.1 Constructability

Extraction technology and equipment exist and are proven. Alternative specific technology will be proven through treatability studies. The treatment and contaminant separation processes would require detailed design and engineering. This alternative rates average in this category.

5.9.3.2 Reliability

This alternative is good in this category due to the use of proven technologies and the effective treatment and storage of waste.

5.9.3.3 Maintenance/Operation

Perpetual maintenance and monitoring would be required to ensure that the on-site disposal facility continues to meet the remedial action objectives. This alternative rates average in this category.

5.9.3.4 Agency Approvals

This alternative is below average in this category because, in spite of the effective waste treatment and stabilization, it provides a lower level of long-term human health and environmental protection due to on-site disposal.

5.9.3.5 Special Engineering and Equipment

This alternative rates below average in this category. The stabilization and contaminant separation processes will require treatability studies and detailed design and engineering.

5.9.4 Cost

The estimated cost for this alternative is $58 million. No credit is taken for the precious metals values.

5.9.5 Additional Data Needs

As previously stated, the stabilization and contaminant separation processes require treatability studies to determine effectiveness and process parameters.

5.9.6 Screening Summary

Although the waste is highly immobile and greatly reduced in volume, their continued presence on site in a concentrated form is the primary disadvantage of this alternative.

5.10 ALTERNATIVE 9 - REMOVAL, CONTAMINANT SEPARATION, AND OFF-SITE DISPOSAL - K-65 SILOS

5.10.1 Description

This alternative is identical to Alternative 8, with the exception that the treated and separated waste would be transported to an approved off-site disposal facility, thereby precluding the need for an on-site disposal facility. The additional requirements to be met by this alternative involve packaging and transportation for disposal (Figure 5-6).

5.10.1.1 System Requirements

This alternative requires:

- EIE
- Miscellaneous utilities
- Waste removal and handling equipment
- Waste treatment and contaminant separation equipment
- Treatability testing for leaching and separation
- Packaging and shipping method
- Approved off-site disposal facility

5.10.1.2 Size and Configuration

The waste removal method and stabilization option selected will have a bearing on the size and configuration of the equipment installed. The configuration, required equipment, and capacities for the removal methods are identical to that for Alternative 3 and will not be described here.

Conventional stabilization requires process equipment that includes driers, mixers, conveyors, and some type of automated packaging equipment. Vitrification requires specialized equipment such as a glass melter, fume hood/cap, and an air pollution control system. Either of these stabilization methods require support facilities separate from those supporting removal activities.

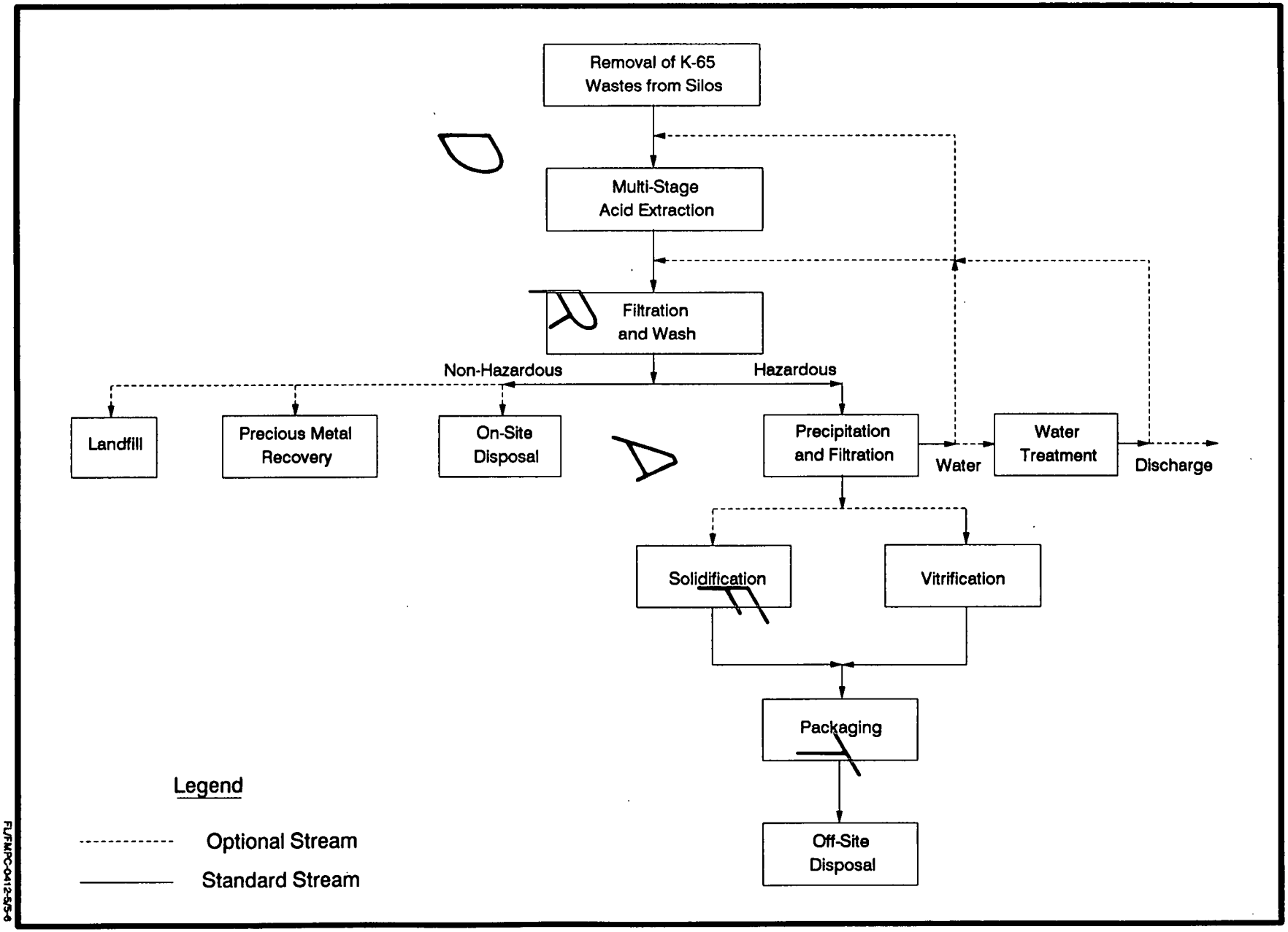


FIGURE 5-6. ALTERNATIVE 9 - REMOVAL, CONTAMINANT SEPARATION, OFF-SITE DISPOSAL - SILOS 1, 2

FL/FMPC-0412-5/5-6

DRAFT

The contaminant separation equipment would consist of a series of agitated batch tanks, precipitation tanks, and associated piping and hardware.

5.10.1.3 Remediation Time Frame

Installation of the EIE, including all of the removal, stabilization, contaminant separation, and packaging equipment, would take approximately 5 months. Removal of the material, treatment/separation, and packaging would take an additional 18 months. Demolition and disassembly/de-mobilization requires approximately 6 months. The total remediation time for this alternative is approximately 3 years.

5.10.1.4 Spatial Requirements

The spatial requirements are:

- EIE (260 ft x 140 ft) — 36,400 sq ft
- Process/packaging building adjacent to EIE (120 ft x 120 ft) — 14,400 sq ft

5.10.1.5 Packaging/Transportation Requirements

The packaging option available for the residual waste is Type B containers. Type A quantities, Limited Quantities, and LSA containers will not be considered for the reasons stated in Section 2.9, and LSA containers will not be considered since the addition of waste-blending material to meet LSA specific activity limits would nullify the waste volume reduction achieved by the alternative.

No waste blending will be required for shipment of the residual waste as Type B quantities, as there are no activity limits for Type B packaging. The residual waste would be placed in 55-gallon drums and packed into Type B overpacks. The less contaminated berm material could be shipped as LSA quantities in 96-cubic-foot LSA boxes. Both the LSA boxes and Type B overpacks would be transported by truck or rail to an approved off-site disposal facility.

5.10.1.6 Waste Generated

The following waste would be generated:

- Wastewater from hydraulic removal method (recycled where possible)
- Water from dehumidication of EIE air
- Nitric acid waste stream to be treated in the on-site biodenitrification pond
- Compactable, low-level waste (anti-contamination clothing, gloves, HEPA filters, etc.)
- Any equipment too contaminated to warrant decontamination

5.10.1.7 Permits Required

Should it be necessary to discharge to the air or water, substantive conditions of the existing NESHAP or NPDES permits would be complied with. Permits/licenses would be required to transport the waste to an approved off-site disposal facility.

5.10.2 Effectiveness

5.10.2.1 Protection of Human Health

The short-term effectiveness of this alternative is below average due to the extensive waste handling required and the long distance transportation of the waste to an off-site disposal facility.

The long-term effectiveness is good due to the off-site storage of the waste in a facility likely to be more geographically remote and environmentally suitable.

5.10.2.2 Protection of the Environment

The short-term effectiveness is below average for the reasons stated in the previous section.

The long-term effectiveness is good due to the off-site disposal of the treated and separated waste in a geologically stable facility that experiences little precipitation.

5.10.2.3 Reduction in Toxicity, Mobility, and Volume through Treatment

This alternative is good in this category because it very effectively reduces the volume and mobility through contaminant separation and stabilization/vitrification. The resultant radioactive waste, though greatly reduced in volume, would be more concentrated in its separated form.

5.10.3 Implementability

5.10.3.1 Constructability

The technologies presented are available and proven, although the treatment and contaminant separation processes require detailed design and engineering. This alternative rates average in this category.

5.10.3.2 Reliability

This alternative is less reliable than Alternative 8 (good) due to the inherent difficulties in effecting the off-site disposal of the waste. This alternative rates above average in this category.

5.10.3.3 Maintenance/Operation

This alternative is significantly better than Alternative 8 in this regard due to the off-site disposal of the waste. As there are no requirements for local maintenance or monitoring, this alternative is judged to be good in this category.

5.10.3.4 Agency Approvals

This alternative is better than Alternative 8 in this category because an off-site disposal option would provide better long-term human health and environmental protection. There would be numerous regulatory requirements to satisfy before shipping the radioactive waste. This alternative rates average in this category.

5.10.3.5 Special Engineering and Equipment

This alternative rates below average in this category. The stabilization and contaminant separation processes require treatability studies and detailed design and engineering.

5.10.4 Cost

The estimated cost for this alternative is $27 million. No credit is taken for precious metal values.

5.10.5 Additional Data Needs

The stabilization and contaminant separation process require treatability studies to determine effectiveness and process parameters.

5.10.6 Screening Summary

This alternative offers low short-term public health and environmental protection due to on-site waste handling followed by shipment to an off-site disposal facility. The long-term protection is the best of any alternative considered because the smaller quantities of immobilized waste, though more concentrated, are stored off-site in a facility that experiences little precipitation and is situated far from any major population centers.

This alternative is the most effective alternative in meeting the long-term remedial action objectives of all those considered.

DRAFT

6.0

6.0 GENERAL SUMMARY

6.1 ALTERNATIVES RECOMMENDED FOR DETAILED ANALYSIS

Following the evaluation performed in Section 5.0, the alternatives were formally ranked according to their ability to meet the general screening criteria. The following numerical scale was used to rate the alternatives:

- 1=Poor
- 2=Below Average
- 3=Average
- 4=Above Average
- 5=Good

The evaluation criteria were applied equally to all of the alternatives; that is, the criteria were not weighted. Table 6-1 presents this quantitative evaluation. The results show that the alternatives achieved generally similar scores, with the exception of Alternative 5. As a result of Alternative 5 providing significantly less effectiveness than Alternative 3 and 4, the alternative has been eliminated in accordance with 40CFR300.430(e)(7)(i)(Effectiveness). Also relevant to the elimination of Alternative 5 is the requirement for excessive and redundant waste handling at the expense of public health and environmental protection, while failing to offer any advantages not provided by other alternatives.

Due to the relatively close scores of the remaining alternatives in this ranking process, the alternatives listed below are recommended for further development and refinement in the detailed analysis of alternatives:

- 1 - Silo Isolation, Silos 1, 2, 3
- 2 - In Situ Stabilization, Silos 1, 2, 3
- 3 - Removal and On-Site Disposal, Silo 3
- 4 - Removal and Off-Site Disposal, Silo 3
- 6 - Removal, Treatment and On-Site Disposal, Silos 1, 2
- 7 - Removal, Treatment and Off-Site Disposal, Silos 1, 2
- 8 - Removal, Contaminant Separation, and On-Site Disposal, Silos 1, 2
- 9 - Removal, Contaminant Separation, and Off-Site Disposal, Silos 1, 2

Table 6-2 lists the estimated cost for each alternative.

TABLE 6-1
ALTERNATIVE EVALUATION MATRIX

1 = Poor 3 = Average 5 = Good
2 = Below Average 4 = Above Average

Alternative	0	1	2	3	4	5	6	7	8	9
Short-Term Public Health	0	5	3	4	3	3	2	2	3	2
Short-Term Environmental Protection	0	5	3	4	3	3	2	2	3	2
Long-Term Public Health	0	1	3	3	4	2	2	5	2	5
Long-Term Environmental Protection	0	1	4	3	4	2	3	5	2	5
Reduction In Mobility, Toxicity, and Volume	0	3	4	3	3	3	4	4	5	5
Constructability	5	5	3	3	3	2	3	3	3	3
Reliability	2	4	3	5	4	2	5	4	5	4
Maintenance	5	3	3	3	5	3	3	5	3	5
Agency Approvals	0	2	2	2	3	1	2	3	2	3
Special Engineering & Equipment	5	5	1	3	3	3	3	3	2	2
Summation	17	34	29	33	~~35~~	24	29	36	30	36

117

TABLE 6-2

COST ESTIMATES FOR REMEDIAL ACTION ALTERNATIVES

Alternative	Description	Capital Cost
0	No action	$1M[a]
1	Nonremoval, Silo Isolation, Silos 1,2,3	$13M
2	Nonremoval, In Situ Stabilization and Cap, Silos 1,2,3	$24M/$19M[b]
3	Removal and On-Site Disposal, Silo 3	$49M
4	Removal and Off-Site Disposal, Silo 3	$9M/$25M[c]
5	Removal and Replacement in Rehabilitated Silo, Silo 3	-[d]
6	Removal, Treatment, and On-Site Disposal, Silos 1,2	$65M
7	Removal, Treatment, and Off-Site Disposal Silos 1,2	$37M/$42M[c]
8	Removal, Contaminant Separation, and On-Site Disposal, Silos 1,2	$58M
9	Removal, Contaminant Separation, and Off-Site Disposal, Silos 1,2	$27M

Notes: [a]$1M = $1,000,000
[b]Vitrification/chemical stabilization
[c]Wastes shipped as LSA/Type B
[d]Alternative eliminated before costing

6.2 ADDITIONAL DATA NEEDS

The alternative evaluation and screening are based on the limited information currently available. Given this lack of information (i.e., operable unit characterization, treatability studies, ARARs, etc.), it is not possible, or prudent, to screen out a number of competing technologies and alternatives. These technologies and alternatives, therefore, must be carried into the subsequent detailed analysis of alternatives where they will be evaluated and screened in the light of available information.

6.2.1 Sampling/Studies

There have been a number of silo sampling studies performed over the years: Vitro Corporation in 1952, Litz in 1974, National Lead of Ohio, Inc., and Battelle Columbus Laboratories in 1980, but these studies have produced analytical results with some variability, indicating the silo residues are not totally homogeneous. Because of this variability, the data from these sampling efforts are not sufficiently complete to adequately characterize the silo residues for the purposes of evaluating remedial actions. A silo sampling plan has been prepared so that additional radiological, chemical and geotechnical properties of the silo waste can be determined.

The lack of representative radiological data on the silo waste directly affects the evaluation of the technologies employed for waste handling, packaging and shipping. Analytical data on the soils beneath the silos is required to determine the presence of leachates and subsequent contaminant migration. Additional geotechnical data for the silo waste and subsoils are required to refine and evaluate the technologies employed for waste removal and capping. In addition, treatability studies are planned which will help determine process parameters and the effectiveness of waste treatment options. All of these sampling activities and studies are scheduled and will be included in the FS report at a later date.

6.2.2 ARARs

The ARARs for Operable Unit 4 are separately discussed in Appendix A.

6.3 DETAILED ANALYSIS PREVIEW

The detailed analysis of alternatives follows the development and screening of alternatives and precedes the ultimate selection of a remedial action. The screened alternatives will be refined

to provide greater detail and accuracy based on the results of additional analyses, treatability studies, and site characterization. During the detailed analysis, each alternative is assessed against the criteria below:

- Overall protection of human health and environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction in toxicity, mobility, and volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

This approach to analyzing alternatives is designed to provide decision makers with sufficient information to adequately compare the alternatives, select an operable unit remedy, and demonstrate satisfaction of the CERCLA remedy selection requirements in the Record of Decision (ROD).

DRAFT

REFERENCES

Camargo Associates, 1986, "K-65 Silos Study and Evaluation for the Feed Materials Production Center," prepared for the Feed Materials Production Center, Cincinnati, Ohio.

Litz, J.E., 1974, "Treatment of Pitchblende Residues for Recovery of Metal Values," Hazen Research, Inc., for Cotter Corp., Canon City, CO.

NLO, Inc., and Battelle Columbus Laboratories, 1980, "Scoping Investigation of Short-Term and Long-Term Storage Costs for Afrimet Residues-NFSS and FMPC," Report to the U.S. Dept. of Energy, Remedial Action Program Office, Washington, D.C.

Vitro Corp., 1952, "Summation Report: Recovery of Radium from K-65 Residue," U.S. Atomic Energy Commission, KLX-1222.

U.S. Department of Energy, 1987, "Remedial Investigation and Feasibility Study, Feed Materials Production Center, Fernald, Ohio, Task 1 Report: Description of Current Sitation," DOE, Oak Ridge Operations Office, Oak Ridge, TN.

U.S. Environmental Protection Agency, Oct. 1988, "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA," Office of Emergency and Remedial Response, EPA, Washington, D.C. pp. 6-7 through 6-9.

DRAFT

APPENDIX

APPENDIX A

ARARs

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

A.1 INTRODUCTION

In performing the Remedial Investigation/Feasibility Study (RI/FS) and subsequent remedial actions for Operable Unit 4 within the Comprehensive Environmental Response, Compensation, and Liability Act/Superfund Amendments and Reauthorization Act of 1986/National Contingency Plan (CERCLA/SARA/NCP) framework, the Feed Materials Production Center (FMPC) is required to comply with all applicable or relevant and appropriate requirements. The purpose of this appendix is to list potential ARARs and/or their sources. This information was presented to DOE on June 13, 1989 in the Initial Screening of Alternatives presentation and, is based on project and regulatory information available at the time.

Applicable requirements are those federal and state requirements that specifically address a hazardous substances, pollutant, contaminant remedial action location, or other circumstances found at a CERCLA site, per NCP at 40CFR300.400(e)(Permit Requirements). Examples of federal statutes specifically cited in CERCLA from which requirements may apply include the Toxic Substances Control Act (TSCA) 15USC2601, the Safe Drinking Water Act (SDWA) 42USC300, the Clean Air Act (CAA) 42USC7401, the Clean Water Act (CWA) the Solid Waste Disposal Act (SWDA) 42USC3251, and the Marine Protection Research and Sanctuaries Act (MPRSA). Relevant and appropriate requirements are those federal and state human health and environmental regulatory requirements that apply to circumstances sufficiently similar to the release or remedial action contemplated (relevant) and are well-suited to the site (appropriate), 40CFR300.400(g)(identification of applicable or relevant and appropriate requirements).

A.2 POTENTAL ARARs FOR OPERABLE UNIT 4

In accordance with current Environmental Protection Agency (EPA) guidance, ARARs are to be progressively developed and applied on a site-specific basis as the RI/FS proceeds. The initial step in the process entails the listing of all potential ARARs for the remedial action process at the subject site. A comprehensive listing of potential ARARs for all of the operable units for the FMPC was completed as part of the Feasibility Study Work Plan. The potential ARARs for the FMPC were categorized into the following EPA-recommended classifications:

- Chemical-Specific ARARs - Usually health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values for each chemical of concern. These values

establish the acceptable amount or concentration of a chemical that may be found in or discharged to the ambient environment.

- Location-Specific ARARs - Restrictions placed on the concentration of a chemical or the conduct of activities solely because they occur in special locations.

- Action-Specific ARARs - Usually technology- or activity-based requirements or limitations on actions taken with respect to waste management and site cleanup.

A brief discussion of each of the primary federal and state of Ohio ARARs, along with pertinent agency-issued criteria, advisories, and guidance is given below. A summary listing of potential ARARs is found in Table A-1.

Federal ARARs

Federal ARARs and other criteria, advisories, or guidelines, include the following:

- Safe Drinking Water Act (42USC300f, et. seq. and 40CFR141 to 149) - Establishes Maximum Contaminant Levels (MCLs) which are enforceable standards for chemicals in public drinking water supplies. They not only consider health factors but also the economic and technical feasibility of removing a contaminant from a water supply system. The EPA has recently proposed MCL goals (MCLGs) for several organic and inorganic compounds in drinking water. MCLGs are nonenforceable guidelines that do not consider the technical feasibility of contaminant removal. The SDWA also authorizes the following programs:

  - The Underground Injection Control (UIC) Program
  - The Sole-Source Aquifer Program
  - The Wellhead Protection Program

- Toxic Substances Control Act (15USC2601, et. seq. and 40CFR702 to 799) - - Regulates the use and disposal of polychlorinated biphenyls (PCBs) and asbestos.

- Resource Conservation and Recovery Act (42USC6901, et. seq. as amended and 40CFR260 to 279) - Establishes the criteria and standards for identification, management, and disposal of hazardous waste.

- Federal Water Pollution Control Act, As amended by the Clean Water Act (33USC-1251, et. seq. and 40CFR104 to 140) - Governs point-source discharges through the National Pollutant Discharge Elimination System (NPDES), dredge and fill activities which may degrade or disturb wetlands or other aquatic habitats, and oil or hazardous substance spills to waters of the United States.

- Ambient Water Quality Criteria - Criteria for 64 chemicals were established in 1980, pursuant to Section 304(a)(1) of the CWA. AWQC are available for the protection of human health from exposure to chemicals in drinking water, from ingestion of aquatic biota, and for the protection of fresh-water and salt-water aquatic life.

- Regulation of Activities Affecting Waters of the U.S. (33CFR320 to 329) - U.S. Army Corps of Engineers (COE) regulations that are applicable to wetlands and navigable waters.

- Occupational Safety and Health Act (29USC651, et. seq. and 29CFR1904, 29CFR1910, and 29CFR1926) - Provides occupational safety and health requirements applicable to workers engaged in on-site field and remediation activities.

- Endangered Species Act of 1978 (16USC1531, et. seq.) - Provides for consideration of the impacts of remedial actions on endangered and threatened species.

- Fish and Wildlife Coordination Act (16USC661, et. seq.) -Provides for consideration of the impacts on wetlands and protected habitats.

- Fish and Wildlife Improvement Act of 1978 (16USC742a) - Provides for consideration of the impacts on wetlands and protected habitats.

- Clean Air Act (42USC4701, et. seq.) - Through the National Ambient Air Quality Standards (NAAQS) it identifies primary and secondary standards for six "criteria" pollutants, and through the National Emission Standards for Radionuclides Emissions from DOE facilities (40CFR61), it provides annual exposure limits from air emissions from DOE facilities.

- EPA Regulations for Environmental Radiation Protection Standards for Nuclear Power Operations (40CFR190) - Applies to radiation doses received by members of the public in the general environment and to radioactive materials introduced into the general environment as a result of operations which are part of the nuclear fuel cycle.

- EPA Regulations for Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40CFR192) - Applies to the control of residual radioactive material at designated processing or repository sites under Section 108 of the Uranium Mill Tailings Radiation Control Act of 1978 and to restoration of such sites following any use of subsurface minerals under Section 104 (h) of the above-referenced act.

- NRC Regulations for Standards for Protection against Radiation (10CFR20) - Establishes standards for protection against radiation hazards arising out of activities under licenses issued by the U.S. Nuclear Regulatory Commission (NRC) and issued pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974.

- The Atomic Energy Act of 1954 (42USC2011, as amended) - Authorizes the conduct of atomic energy activities.

- Licensing Requirements for Land Disposal of Radioactive Waste (10CFR61) - Establishes procedures and criteria for the land disposal of radioactive wastes.

State of Ohio ARARs

State of Ohio ARARs and other criteria, advisories, or guidance include the authority of the Ohio Environmental Protection Agency (OEPA) to manage federal environmental programs. OEPA shares several responsibilities with other Ohio agencies including the Department of Health, the Department of Natural Resources (ODNR), and the Public Utilities Commission:

- Ohio Water Pollution Control Act (ORC Chapter 6111) - OEPA has the authority to administer all of the federally mandated water discharge programs, including the NPDES programs for all source categories (OAC3745-33-01 through 3745-33-05), and an effective pretreatment program (OAC3745-3).

- Solid and Hazardous Waste Disposal Law (ORC Chapter 3734) - OEPA has been developing extensive solid and hazardous waste regulations (OAC3745 Chapters 27-70). These programs are administered by the Solid and Hazardous Waste Division of OEPA.

- Water Quality Standards (OAC3745-1) - Ohio has developed water quality standards applicable to state surface water (OAC3745-1-04), an antidegradation policy (OAC3745-1-05) and has designated water use criteria for all major surface water bodies (OAC3745-1-07 to 32).

- Drinking Water Rules - The rules for public drinking water are set forth by OAC3745-81-01 to 55, and includes MCLs. OAC3745-82 sets secondary contaminant standards.

- Water Well Installation - For new wells intended for human consumption, well installation is regulated under OAC3745-9 by OEPA and ODNR.

- The Underground Injection Well Control Program - Approvals for injection wells are required from the ODNR and OEPA. The requirements for permits to inject fluids via wells are set forth in OAC3745-34.

- Water System - Authority to establish and enforce rules regarding private water systems is granted to the Department of Health under OAC3701. The Department of Health governs plan approvals, procedures, construction, and abandonment for private water systems (OAC3701-38). Community and public water supply systems are governed and approved by the OEPA under OAC3745-83 to 95.

- Radiation Standards - Standards for protection and handling of equipment and materials associated with ionizing radiation are governed by rules set by the Department of Health under OAC3701-38.

- Air Pollution Control - Establishes the authority of Ohio EPA to regulate and control air pollution within the state under ORC 3704.03. Requires person responsible for any air contaminant source to install, employ, maintain, and operate such emissions, ambient air quality, meteorological, or other monitoring devices or methods as director prescribes. Requires the sampling of emissions at such locations, intervals and in a manner which the director prescribes. Requires the maintenance of records and filing of periodic reports with the director on the

location, size, and height of emissions outlets, as well as the rate, duration, and composition of emissions.

Ohio regulations will be analyzed for status as ARARs as they are applied to the alternatives. That is, that they are promulgated (of identified by the state in a timely manner [40CFR300.515(d)(2) and (h)(2)(State Involvement in RI/FS Process and Requirements for State Involvement in Absence of SMOA], and are more stringent than federal requirements and therefore are potential ARARs. State involvement if RI/FS process and requirements for state involvement in absence of SMOA.

A.3 GUIDANCE TO BE CONSIDERED (TBC)

Because ARARs may not exist or may not be sufficient to protect human health and the environment at a CERCLA site, it is necessary to evaluate nonlegally binding or non-promulgated criteria, advisories, guidance, or policies for protective cleanup levels when determining cleanup requirements or designing a remedy. EPA and support agencies may, as appropriate, identify other advisories, criteria, or guidance to be considered for a particular remediation activity. This TBC category consists of advisories, criteria, or guidance that were developed by EPA, other federal agencies, or states that are not ARARs.

The application of the ARARs to Operable Unit 4 at the FMPC is complicated by the fact that the DOE and radionuclides (particularly uranium) have been exempted from most environmental regulations. From a radiological standpoint, the DOE has been primarily self-regulating for environmental activities, and established its own policies for environmental monitoring, waste disposal, and limits of exposure to employees and the public. EPA regulations regarding the handling and disposal of wastes containing radionuclides are under programs set up by the Uranium Mill Tailings Act and the NRC. It should also be noted that DOE orders are not promulgated requirements but fall under the category of TBCs.

A brief discussion of each of the primary Federal TBCs presently being considered is given below.

FEDERAL TBCs

- Health Effects Assessments - Presents toxicity data for specific chemicals for use in public health assessments. Also considered applicable are slope factors and referenced doses provided in the Human Health Evaluation Manual (EPA 1989).

- Groundwater Protection Strategy - Documents EPA policy to protect groundwater for its highest present or potential beneficial use. The strategy designates three categories of groundwater:

  - Class 1 - Special Groundwaters: Waters that are highly vulnerable to contamination and are either irreplaceable or ecologically vital sources of drinking water.

  - Class 2 - Current and Potential Sources of Drinking Water and Waters Having other Beneficial Uses: Waters that are currently used or that are potentially available for use.

  - Class 3 - Groundwater not a Potential Source of Drinking Water and of Limited Beneficial Use: Class 3 groundwater units are further subdivided into the following two subclasses:

    a. Subclass 3A includes groundwater units that are highly to intermediately interconnected to adjacent groundwater units of a higher class and/or surface waters. They may, as a result, be contributing to the degradation of the adjacent waters. They may be managed at a similar level as Class 2 groundwaters, depending upon the potential for producing adverse effects on the quality of adjacent waters.

    b. Subclass 3B is restricted to groundwater units characterized by a low degree of interconnection to adjacent surface waters or other groundwater units of a higher class within the Classification Review Area. These groundwaters are naturally isolated from sources of drinking water in such a way that there is little potential for producing adverse effects on quality. They have low resource value outside of mining or waste disposal.

- DOE Order for CERCLA Program (5400.4) (Draft) - Provides direction for DOE to implement a CERCLA program.

- DOE Order for Radiation Protection of the Public and the Environment (5400.5) (February 8, 1990) - Establishes standards and requirements with respect to protection of the public and the environment against radiation.

- DOE Order for Hazardous and Radioactive Mixed Waste Management (5480.2) (December 13, 1982) - Establishes hazardous waste management procedures for facilities operated under authority of the Atomic Energy Act of 1954, as amended.

- DOE Order for Environmental Protection, Safety, and Health Protection Information Reporting Requirements (5484.1) (February 24, 1981) - Establishes the requirements and procedures for reporting and investigating matters of environmental protection, safety, and health protection significant to DOE operations.

- DOE Order for Quality Assurance (5700.6B) (September 23, 1986) - Establishes DOE's quality assurance program.

- DOE Order for Radioactive Waste Management (5820.2A) (September 26, 1988) - Establishes policies and guidelines for the management of radioactive waste and contaminated facilities.

- DOE Order for Radiation Protection for Occupational Workers (5480.11) (December 21, 1988) - Establishes standards and requirements with respect to protection of the occupational worker against radiation.

A summary listing of TBCs is found in Table A-1.

A.4 SUMMARY

The establishment of final federal and state ARARs and TBCs for uranium and other constituents found in the operable unit for the evaluation of remedial action alternatives for Operable Unit 4 at the FMPC will be a progressive, multi-step process involving interactive discussions among DOE, EPA, and OEPA. The critical application of the final ARARs will be performed during the detailed analysis of alternatives. The ARARs, in conjunction with the baseline risk assessment, will assist in the determination of the cleanup levels required to adequately protect public health and the environment at the FMPC.

DRAFT

TABLE A-1
SUMMARY LIST OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND GUIDANCE TO BE CONSIDERED

Chemical-Specific ARARs

Requirement	Description
Resource Conservation and Recovery Act (RCRA), Subtitle C (42USC6901, et. seq.)	Sets standards applicable to hazardous waste treatment, storage, and disposal
Safe Drinking Water Act (42 USC300, et. seq.)	
a. Maximum contaminant levels (MCLs) b. Maximum contaminant level goals (MCLGs)	Remedial actions may provide cleanup to the MCLs considered pursuant to SARA Section 121(d)(2)(A)(ii)
Clean Water Act Ambient Water Quality Criteria (33USC1313, et. seq.)	Remedial actions may involve discharge to surface waters
EPA Regulations for Environmental Radiation Protection Standards for Nuclear Power Operations (40CFR190)	40CFR190 establishes radiation dose limits to the public of annual dose equivalents not to exceed 25 mrem to the whole body
EPA Regulations for Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40CFR192)	Establishes cleanup limits for uranium and thorium mill tailings in soil and groundwater
Clean Air Act (42USC7401, et. seq.)	
a. National Ambient Air Quality Standards (NAAQS) for six criteria pollutants (40CFR50)	Identifies primary and secondary standards for six "criteria pollutants" (i.e., lead, particulates)
b. National Emission Standards for Radionuclides Emissions from DOE Facilities (40CFR61, Subpart H)	Provides annual limits of 10 mrem/yr (whole body) for air emissions from DOE facilities
c. National Emission Standards for Radon Emissions for U.S. DOE Facilities (40CFR61, Subpart Q)	Provides annual limits for air emissions of radon from DOE facilities
NRC Licensing Requirements for Land Disposal of radioactive Waste (10CFR61)	Provides for protection of the general population from releases of radioactivity (<25 mrem/yr)
NRC Regulations for Standards for Protection Against Radiation (10CFR20)	Establishes dose limits in unrestricted areas (10CFR20.105-106) and for waste disposal (10CFR20.301-302)

TABLE A-1 (Continued)
SUMMARY LIST OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND GUIDANCE TO BE CONSIDERED

Chemical-Specific ARARs

Requirement	Description
Ohio Regulations	
a. Air Pollution	Escape, releases, emissions to open air
OAC3745-17-07	Non-degradation policy
OAC3745-17-05	Particulate emissions to air
OAC3745-17-07	Fugitive dust emissions
OAC3745-17-08	Emissions of organics to air
OAC3745-21-07	Air quality
b. Water Pollution	
OAC3745-81	Drinking water rules, sets MCLs for gross alpha, beta and radium 226 and radium 228
OAC3745-1	Water Quality standards, 3745-01-4(D) sets the criterion applicable to all waters, 3745-01-05 sets forth the antidegradation policy for state waters, 3745-01-21 describes use designations for the Great Miami River, 3745-1-32 (c) (9) specifically excludes uranium from the Ohio River
c. Other Regulations	
OAC3701-38	Ohio Radiation Protection Standards provide concentration limits for discharge of radioactive materials into air or water in unrestricted areas

TABLE A-1 (Continued)
SUMMARY LIST OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND GUIDANCE TO BE CONSIDERED

Location-Specific ARARs	
Requirements	Description
Rivers and Harbors Act of 1899 (33CFR320 to 327)	Remedial alternatives may effect the Great Miami River
Ohio Location Standards (OAC3745-54-18)	Governs the location of hazardous waste treatment, storage, or disposal with respect to seismic conditions and floodplains
Fish and Wildlife Improvement Act of 1978 (16USC742, et. seq.)	The effects of No Action and the construction, demolition, and discharge activities must be considered if endangered species are located in an area impacted by Operable Unit 4
Regulations of activities affecting waters of the U.S. (33CFR320 to 329)	COE regulations apply to both wetlands and navigable (33CFR320-329), and for Ohio (OAC3745-32) waters
Endangered Species Act of 1978 (16USC1531, et. seq.)	The effects of No Action and the construction, demolition, and discharge activities must be considered if endangered species are located in area impacted by Operable Unit 4
Fish and Wildlife Coordination Act (16USC1531, et. seq.)	Provides for coordination of the impacts on wetlands and protected habitats

TABLE A-1 (Continued)
SUMMARY LIST OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND GUIDANCE TO BE CONSIDERED

Action-Specific ARARs

Requirements	Description
OSHA Requirements (29CFR1904, 29CFR1910, and 29CFR1926)	Required for workers engaged in on-site remedial activities
Clean Water Act Ambient Water Quality Criteria (33USC1313, et. seq.)	Alternatives include discharge to surface waters
NRC Regulations for Standards for Protection Against Radiation (10CFR20)	Provides standards for discharge of radionuclides to unrestricted areas (air and water) a variety of waste disposal requirements (Licensed materials) and sets guidelines for surveys, personnel monitoring, and other radiation safety requirements
EPA Regulations for Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40CFR192)	Provides standards for control of residual radioactive materials from inactive uranium processing sites
EPA Regulations for National Emission Standards for Radionuclide Emissions from DOE Facilities (40CFR61)	Applies principally to air emissions from DOE facilities
Safe Drinking Water Act (40CFR141 to 149)	Establishes MCLs for potential drinking water sources
Ohio General Radiation Protection Standards (OAC3701 to 70)	Applies to all facilities that receive, possess, use, store, transfer, etc., any source of radiation
Ohio Radiation Protection Standards (OAC3701-38)	Applies to all facilities that receive, possess, use, store, transfer, etc., any source of radiation
Hazardous Waste Transport (OAC3745-53-11)	Remedial alternatives may include off-site transport
Ohio Regulation of Noxious Exhalations, Obstructions, or Pollution of Water Sources, or other Nuisances. (ORC 3767)	Prohibits noxious odors, smells, or pollution of water courses and other nuisances.

TABLE A-1 (Continued)
SUMMARY LIST OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND GUIDANCE TO BE CONSIDERED

TBCs	
Requirements	Description
Executive Order 11990 Protection Of the Wetlands	This order may affect the administrative ability of alternatives which cause disturbance or destruction of wetlands
Threshold Limit Values, American Conference of Governmental Industrial Hygienists	Set requirements for air concentrations during remedial activities
Radioactive Waste Management (DOE Order 5820.2A)	Sets requirements for management of radioactive wastes at DOE facilities
Radiation Protection of the Public and the Environment (DOE Order 5400.5)	Sets requirements for protection of the public and the environment from radioactive materials at DOE facilities
Radiation Protection for Occupational Workers (DOE Order 5480.11)	Sets requirements for protection of workers from radiation and radioactive materials at DOE facilities
CERCLA Program (5400.4) (Draft)	Provides direction for DOE to implement a CERCLA program
Hazardous and Radioactive Mixed Waste Management (5480.2) (December 13, 1982)	Establishes hazardous waste management procedures for facilities operated under authority of the Atomic Energy Act of 1954, as amended
Environmental Protection, Safety, and Health Protection Information Reporting Requirements (5484.1) (February 24, 1981)	Establishes the requirements and procedures for reporting and investigating matters of environmental protection, safety, and health protection significant to DOE operations
Quality Assurance (5700.6B) (September 23, 1986)	Establishes DOE's quality assurance program

APPENDIX

APPENDIX B

SILO ANALYTICAL DATA

DRAFT

FMPC-0412-5
August 05, 1990

RADIONUCLIDE CONCENTRATION IN THE SILO WASTE

SILO 1

Nuclide (pCi/g)	S1NE1A	S1NE1B	S1NE1C	S1SE1	S1SE2	S1SW1	S1NW1
Th-228	ND	ND	ND	ND	ND	ND	ND
Th-230	21,412	39,693	30,751	10,569	20,848	40,818	43,771
Th-232	ND	ND	ND	ND	ND	ND	766
Ra-226	108,100	192,600	166,400	116,800	89,280	181,200	163,300
Ra-228	ND	ND	ND	ND	ND	ND	ND
Pb-210	181,100	83,110	77,460	71,920	48,980	69,480	54,350
U-234	815	326	622	663	814	594	897
U-235/236	ND	ND	ND	ND	56	ND	50
U-238	920	398	610	545	758	532	687
U-Total (ppm)	2753	1189	1831	1633	2280	1602	2066

SILO 2

Nuclide (pCi/g)	S2SW1	S2NW1	S2NE2	S2SW2	S2NE1	S2NW2
Th-228	ND	ND	ND	411	ND	638
Th-230	31,825	32,784	8365	29,716	40,124	25,391
Th-232	ND	ND	ND	851	ND	ND
Ra-226	145,300	61,780	657	104,900	65,520	68,310
Ra-228	ND	ND	ND	ND	ND	ND
Pb-210	141,900	145,200	87,930	77,940	150,700	399,200
U-234	859	1107	974	121	848	1404
U-235/236	ND	74	47	ND	36	70
U-238	661	1069	874	46	814	1240
U-Total (ppm)	1972	3210	2620	137	2437	3717

ND = Not Detected

Note: Data validation is currently in progress
Source: Winter 1989 WMCO sampling

RADIONUCLIDE CONCENTRATION IN THE SILO WASTE (Continued)

SILO 3

Nuclide (pCi/g)	21	22	23	24	25	26
Ac-227	523	416	234	1363	534	706
Pa-231	521	401	266	NA	556	889
Th-228	907	ND	554	ND	459	859
Th-230	41,911	33,881	21,010	71,650	40,968	41,555
Th-232	1451	ND	815	911	411	ND
Ra-224	453	451	64	213	295	335
Ra-226	2589	2192	467	6435	3073	1862
Ra-228	525	559	82	ND	392	441
Pb-210	2437	2221	454	6427	2493	1910
U-234	1935	1618	348	1524	1467	1910
U-235/236	152	117	ND	127	54	76
U-238	2043	1649	320	1600	1392	1860
U-Total (ppm)	4040	4305	738	2595	3064	4554

SILO 3

Nuclide (pCi/g)	27	28	29	30	33
Ac-227	421	412	443	773	566
Pa-231	458	NA	564	931	431
Th-228	ND	996	537	ND	949
Th-230	53,227	63,649	61,190	68,759	65,488
Th-232	ND	755	672	581	672
Ra-224	370	106	137	449	313
Ra-226	1518	3702	4169	2240	4451
Ra-228	325	ND	117	360	415
Pb-210	1084	2589	3553	1942	3674
U-234	1317	1052	1843	1643	1600
U-235/236	80	42	158	75	118
U-238	1243	994	1951	1574	1878
U-Total	2740	1463	1114	4050	3854

NA = Not Analyzed
ND = Not Detected

Note: Data validation is currently in progress
Source: Winter 1989 WMCO sampling

CHEMICAL CONCENTRATION REPORT FOR SILOS 1, 2, AND 3
OPERABLE UNIT 4

PCB Organics Analysis Data (ug/kg)
SILO 1

Sample Location	S1NE1A	S1NE1B	S1NE1C	S1NW1	S1SE1	S1SE2	S1SW1
Aroclor-1248	3700	ND	ND	1700	2500	7300	2400
Aroclor-1254	8100	1100(J)	1300(J)	3900	3500	10,000	5600
Second Dilution			**Second Dilution**				
Aroclor-1248	4100(J)	NA	NA	2800(J)	4000(J)	8000	3200(J)
Aroclor-1254	8700(J)	NA	NA	5700(J)	5800(J)	12,000	6600(J)
Blank Reference	Blank 1	Blank 1	Blank 2	Blank 1	Blank 1	Blank 1	Blank 1

SILO 2

Sample Location	S2NE1	S2NE2	S2NW1	S2NW2	S2SW1	S2SW2
Aroclor-1248	ND	ND	ND	ND	ND	ND
Aroclor-1254	1900	420(J)	3000	1300(J)	3300	3900
Second Dilution			**Second Dilution**			
Aroclor-1248	ND	NA	ND	ND	ND	ND
Aroclor-1254	2000(J)	NA	5400(J)	1500(J)	3700(J)	6000(J)
Blank Reference	Blank 2	Blank 2	Blank 2	Blank 2	Blank 1	Blank 2

SILO 3 and BLANKS

Sample Location	26	27	28	29	Blank 1	Blank 2
Aroclor-1248	ND	ND	ND	ND	ND	ND
Aroclor-1254	ND	ND	ND	ND	ND	ND
Second Dilution		**Second Dilution**				
Arcolor-1248	NA	NA	NA	NA		
Aroclor-1254	NA	NA	NA	NA		
Blank Reference	Blank 1	Blank 1	Blank 1	Blank 1		

Organic Qualifiers
J - Copmpound detected below the contract required quantification limit (CRQL)
ND - Compound analyzed for but not detected
B - Compound was found in the method blank
NA - Not analyzed
Note 1: S1 indicates Silo 1, S2 indicates Silo 2, 21-33 indicate Silo 3
Note 2: Data validation is currently in progress
Source: Winter 1989 WMCO sampling.

CHEMICAL CONCENTRATION REPORT FOR SILOS 1, 2, AND 3
OPERABLE UNIT 4

Inorganics Analysis Data (mg/kg)
SILO 1

Sample Location	S1NE1A	S1NE1B	S1NE1C	S1NW1	S1SE1	S1SE2	S1SW1
Parameter							
Aluminum	1260	60.4	1380	450	364	1430	733
Antimony	ND	ND	ND	ND	ND	ND	ND
Arsenic	57.0	47.9	45.8	54.5	14.7	68.4	61.0
Barium	4340	1970	4140	5000	2720	2190	7860
Beryllium	2.8	1.3	1.4	1.1	0.88(B)	2.4	1.3
Cadmium	4.4	2.3	2.9	2.1	3.0	8.0	2.7
Calcium	5580	2320	2150	4130	3500	5700	5410
Chromium	43.3	25.8	22.8	21.0	165	111	42.6
Cobalt	1260	404	1210	681	349	814	657
Copper	473	122	410	217	126	307	209
Iron	24,100	9090	7170	4340	22,600	75,100	8370
Lead	35,800	61,400	85,100	81,300	38,900	38,800	76,900
Magnesium	2770	3270	3620	1900	1500	6020	2830
Manganese	178	36.5	83.1	33.5	94.2	257	54.0
Mercury	2.8	0.47	0.72	0.43	0.23	0.60	0.56
Nickel	1970	815	2580	1180	629	1350	1140
Potassium	158(B)	347(B)	424(B)	350(B)	173(B)	293(B)	492(B)
Selenium	172	139	170	162	106	180	168
Silver	9.8	5.0	23.3	9.5	6.3	13.1	9.8
Sodium	360(B)	5730	13,100	7080	1640	2610	7010
Thallium	0.09(B)	0.38(B)	ND	0.49(B)	0.24(B)	ND	0.52(B)
Vanadium	240	111	110	105	72.2	140	106
Zinc	212	14.4	26.3	24.7	23.9	57.3	17.8
Cyanide	0.52	1.4	1.4	2.9	0.99	1.6	4.4

Inorganic Qualifiers
ND - Compound analyzed for but not detected above instrument detection level (IDL)
B - Compound found between IDL and CRQL

Note 1: S1 indicates Silo 1, S2 indicates Silo 2, 21-33 indicate Silo 3
Note 2: Data validation is currently in progress
Source: Winter 1989 WMCO sampling

CHEMICAL CONCENTRATION REPORT FOR SILOS 1, 2, AND 3
OPERABLE UNIT 4

Inorganics Analysis Data (mg/kg) (Continued)
SILO 2

Sample Location	S2NE1	S2NE2	S2NW1	S2NW2	S2SW1	S2SW2
Parameter						
Aluminum	2570	1360	1250	1180	464	551
Antimony	ND	ND	ND	ND	7.2(B)	6.4(B)
Arsenic	1960	330	71.3	57.5	81.4	64.5
Barium	2460	89.2	1190	3090	8370	8000
Beryllium	2.0	0.66(B)	6.0	2.7	1.6	2.1
Cadmium	19.1	4.1	5.6	5.0	3.6	3.4
Calcium	41,900	301,000	10,300	2430	3610	8570
Chromium	42.2	12.9	68.8	47.2	24.3	34.1
Cobalt	2430	6.2(B)	648	543	692	602
Copper	1790	ND	220	221	263	249
Iron	13,500	4010	37,800	26,900	8330	11,400
Lead	21,600	153	15,100	17,600	28,500	29,800
Magnesium	7390	8740	4200	4220	1520	2060
Manganese	403	335	170	160	74.2	83.2
Mercury	1.0	2.3	1.7	0.37	ND	0.34
Nickel	2200	14.6	878	787	1070	897
Potassium	207(B)	37.8(B)	271(B)	192(B)	118(B)	289(B)
Selenium	91.1	ND	117	95.9	118	105
Silver	22.8	ND	9.1	12.0	7.4	10.1
Sodium	4070	588(B)	912	226(B)	3100	857
Thallium	0.61(B)	ND	0.33(B)	0.39(B)	1.4(B)	0.82(B)
Vanadium	142	21.9	214	211	151	193
Zinc	154	11.2	31.6	70.8	25.8	25.7
Cyanide	1.1	ND	4.5	0.90	2.5	1.6

Inorganic Qualifiers
ND - Compound analyzed for but not detected above instrument detection level (IDL)
B - Compound found between IDL and CRQL

Note 1: S1 indicates Silo 1, S2 indicates Silo 2, 21-33 indicate Silo 3
Note 2: Data validation is currently in progress
Source: Winter 1989 WMCO sampling

CHEMICAL CONCENTRATION REPORT FOR SILOS 1, 2, AND 3
OPERABLE UNIT 4

Inorganics Analysis Data (mg/kg) (Continued)
SILO 3

Sample Location	21	22	23	24	25	26	27
Aluminum	21,300	18,000	18,000	23,700	15,800	10,800	20,800
Antimony	ND	ND	ND	ND	ND	ND	ND
Arsenic	1380	2450	1610	6380	2200	532	1460
Barium	297	253	332	194	210	118	319
Beryllium	20.8	20.6	39.9	35.1	26.5	10.0	25.2
Cadmium	41.7	60.3	40.1	204	62.4	21.5	45.5
Calcium	39,500	33,100	32,600	23,300	25,800	21,300	39,900
Chromium	260	171	421	139	213	170	335
Cobalt	2580	1100	1340	1870	1340	ND	2190
Copper	2020	2430	1610	7060	2440	1620	2140
Iron	41,700	26,200	60,400	13,900	31,200	28,200	67,600
Lead	1700	1440	646	4430	1310	1510	1130
Magnesium	74,400	62,400	44,900	38,200	44,100	44,800	72,400
Manganese	5200	3610	6500	2420	3980	2700	5790
Mercury	ND	ND	ND	0.30	ND	0.69	ND
Nickel	3280	1200	1810	2280	1760	6170	3150
Potassium	5310	3880	22800	4520	7360	3300	13600
Selenium	159	108	129	122	105	349	192
Silver	23.8	21.5	9.2	14.8	14.3	14.9	20.2
Sodium	30,100	43,100	44,100	38,100	31,200	22,900	39,500
Thallium	10.0	37.6	6.5	73.9	35.8	7.2	11.9
Vanadium	1180	2030	1420	4550	2030	499	1270
Zinc	497	361	637	387	380	301	563
Cyanide	ND	ND	ND	ND	ND	ND	ND

Inorganic Qualifiers
ND - Compound analyzed for but not detected above instrument detection level (IDL)
B - Compound found between IDL and CRQL

Note 1: S1 indicates Silo 1, S2 indicates Silo 2, 21-33 indicate Silo 3
Note 2: Data validation is currently in progress
Source: Winter 1989 WMCO sampling

CHEMICAL CONCENTRATION REPORT FOR SILOS 1, 2, AND 3
OPERABLE UNIT 4

Inorganics Analysis Data (mg/kg) (Continued)
SILO 3

Sample Location	28	29	30	33
Aluminum	14,800	13,500	15,300	17,500
Antimony	ND	ND	ND	ND
Arsenic	1420	1010	1060	1980
Barium	142	118	215	185
Beryllium	31.2	13.9	16.6	26.4
Cadmium	69.8	24.2	35.1	52.7
Calcium	26,200	25,600	29,900	25,900
Chromium	560	443	236	221
Cobalt	2800	3520	2950	1350
Copper	2760	1640	2010	2280
Iron	45,000	40,000	37,800	23,800
Lead	1800	1960	1330	1750
Magnesium	71,400	80,900	58,100	52,800
Manganese	5940	5290	3970	2780
Mercury	ND	ND	0.30	ND
Nickel	3040	3830	4230	1970
Potassium	3740	1300	6690	7340
Selenium	204	186	254	101
Silver	13.3	9.5	17.4	16.1
Sodium	51,700	27,000	30,400	39,000
Thallium	5.5	4.0	13.7	3.1
Vanadium	2540	418	1040	3040
Zinc	672	449	397	306
Cyanide	ND	ND	ND	ND

Inorganic Qualifiers
ND - Compound analyzed for but not detected above instrument detection level (IDL)
B - Compound found between IDL and CRQL

Note 1: S1 indicates Silo 1, S2 indicates Silo 2, 21-33 indicate Silo 3
Note 2: Data validation is currently in progress
Source: Winter 1989 WMCO sampling