299

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

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REPORT

INITIAL SCREENING OF ALTERNATIVES FOR OPERABLE UNIT 4

TASK 12 REPORT

FEED MATERIALS PRODUCTION CENTER
FERNALD, OHIO

REMEDIAL INVESTIGATION and FEASIBILITY STUDY

May 1990

U.S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE

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Prepared for

U.S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE

Prepared by

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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 Development of Alternatives	2-1
2.1 Summary	2-1
2.1.1 Remedial Action Objectives	2-1
2.1.2 General Response Actions	2-2
2.1.3 Current Status	2-2
2.2 Summary of Alternatives	2-4
2.2.1 Alternative 0	2-4
2.2.2 Alternative 1	2-4
2.2.3 Alternative 2	2-4
2.2.4 Alternative 3	2-6
2.2.5 Alternative 4	2-6
2.2.6 Alternative 5	2-6
2.2.7 Alternative 6	2-6
2.2.8 Alternative 7	2-6
2.2.9 Alternative 8	2-6
2.2.10 Alternative 9	2-6
3.0 Alternative Screening Methodology	3-1
3.1 Introduction	3-1
3.2 Refinement of Alternatives	3-1
3.3 Alternative Evaluation Process	3-2
3.3.1 Effectiveness Evaluation	3-4

TABLE OF CONTENTS
(Continued)

	PAGE
3.3.2 Implementability and Reliability Evaluation	3-4
3.3.3 Cost Evaluation	3-4
3.3.4 Innovative Technologies	3-5
3.4 Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)	3-5
3.5 Waste Disposal Considerations	3-6
3.5.1 Long-Term Effectiveness	3-6
3.5.2 Short-Term Effectiveness	3-6
3.5.3 Reduction in Toxicity, Mobility, and Volume	3-7
3.5.4 Implementability	3-7
3.5.5 Cost	3-7
3.5.6 Overall Protection of Human Health and the Environment	3-7
3.5.7 Land Disposal Restrictions	3-8
4.0 Technology Refinement	4-1
4.1 Environmental Isolation Enclosure	4-1
4.2 Mechanical, Hydraulic, Pneumatic Removal	4-5
4.2.1 Mechanical Removal	4-5
4.2.2 Hydraulic Removal	4-5
4.2.3 Pneumatic Removal	4-7
4.3 Silo Demolition	4-7
4.4 Stabilization/Vitrification	4-9
4.4.1 Stabilization	4-9
4.4.2 Vitrification	4-10
4.5 Air Treatment Process	4-11
4.6 Water Treatment - Metals Removal, Ion Exchange, and Denitrification	4-11
4.7 Impermeable Cap	4-12
4.8 On-Site Disposal Facility	4-14
4.9 Packaging/Transportation	4-20
4.9.1 Limited Quantities	4-20
4.9.2 LSA	4-20
4.9.3 Type A	4-21
4.9.4 Type B	4-21

TABLE OF CONTENTS
(Continued)

	PAGE
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	5-1
5.1.1.5 Packaging Requirements	5-2
5.1.1.6 Wastes 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	5-2
5.1.3 Implementability	5-2
5.1.3.1 Constructability	5-2
5.1.3.2 Reliability	5-2
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	5-5
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 Wastes Generated	5-5
5.2.1.7 Permits Required	5-5

TABLE OF CONTENTS
(Continued)

		PAGE
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, Volume	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	5-9
5.3.1.2	Size and Configuration	5-9
5.3.1.3	Remediation Time Frame	5-9
5.3.1.4	Spatial Requirements	5-9
5.3.1.5	Packaging Requirements	5-9
5.3.1.6	Wastes Generated	5-9
5.3.1.7	Permits Required	5-10
5.3.2	Effectiveness	5-10
5.3.2.1	Protection of Human Health	5-10
5.3.2.2	Protection of the Environment	5-10
5.3.2.3	Reduction in Toxicity, Mobility, Volume	5-10
5.3.3	Implementability	5-11
5.3.3.1	Constructability	5-11
5.3.3.2	Reliability	5-11
5.3.3.3	Maintenance/Operation	5-11
5.3.3.4	Agency Approvals	5-11

6

TABLE OF CONTENTS
(Continued)

		PAGE
5.3.3.5	Special Engineering and Equipment	5-11
5.3.4	Cost	5-11
5.3.5	Additional Data Needs	5-12
5.3.6	Screening Summary	5-12
5.4	Alternative 3 - Removal and On-Site Disposal - Silo 3	5-12
5.4.1	Description	5-12
5.4.1.1	System Requirements	5-14
5.4.1.2	Size and Configuration	5-14
5.4.1.3	Remediation Time Frame	5-14
5.4.1.4	Spatial Requirements	5-14
5.4.1.5	Packaging Requirements	5-14
5.4.1.6	Wastes Generated	5-15
5.4.1.7	Permits Required	5-15
5.4.2	Effectiveness	5-15
5.4.2.1	Protection of Human Health	5-15
5.4.2.2	Protection of the Environment	5-15
5.4.2.3	Reduction in Toxicity, Mobility, and Volume	5-15
5.4.3	Implementability	5-16
5.4.3.1	Constructability	5-16
5.4.3.2	Reliability	5-16
5.4.3.3	Maintenance/Operation	5-16
5.4.3.4	Agency Approvals	5-16
5.4.3.5	Special Engineering and Equipment	5-16
5.4.4	Cost	5-16
5.4.5	Additional Data Needs	5-16
5.4.6	Screening Summary	5-16

TABLE OF CONTENTS
(Continued)

		PAGE
5.5	Alternative 4 - Removal and Off-Site Disposal - Silo 3	5-17
5.5.1	Description	5-17
5.5.1.1	System Requirements	5-17
5.5.1.2	Size and Configuration	5-17
5.5.1.3	Remediation Time Frame	5-17
5.5.1.4	Spatial Requirements	5-19
5.5.1.5	Packaging/Transportation Requirements	5-19
5.5.1.6	Wastes Generated	5-19
5.5.1.7	Permits Required	5-20
5.5.2	Effectiveness	5-20
5.5.2.1	Protection of Human Health	5-20
5.5.2.2	Protection of the Environment	5-20
5.5.2.3	Reduction in Toxicity, Mobility, Volume	5-20
5.5.3	Implementability	5-20
5.5.3.1	Constructability	5-20
5.5.3.2	Reliability	5-21
5.5.3.3	Maintenance/Operation	5-21
5.5.3.4	Agency Approvals	5-21
5.5.3.5	Special Engineering and Equipment	5-21
5.5.4	Cost	5-21
5.5.5	Additional Data Needs	5-21
5.5.6	Screening Summary	5-21
5.6	Alternative 5 - Removal and Replacement in Rehabilitated Silo - Silo 3	5-22
5.6.1	Description	5-22
5.6.1.1	System Requirements	5-22
5.6.1.2	Size and Configuration	5-22
5.6.1.3	Remediation Time Frame	5-22
5.6.1.4	Spatial Requirements	5-23
5.6.1.5	Packaging Requirements	5-23

TABLE OF CONTENTS
(Continued)

		PAGE
	5.6.1.6 Wastes Generated	5-23
	5.6.1.7 Permits Required	5-23
5.6.2	Effectiveness	5-23
	5.6.2.1 Protection of Human Health	5-23
	5.6.2.2 Protection of the Environment	5-24
	5.6.2.3 Reduction in Toxicity, Mobility, Volume	5-24
5.6.3	Implementability	5-24
	5.6.3.1 Constructability	5-24
	5.6.3.2 Reliability	5-24
	5.6.3.3 Maintenance/Operation	5-24
	5.6.3.4 Agency Approvals	5-24
	5.6.3.5 Special Engineering and Equipment	5-25
5.6.4	Cost	5-25
5.6.5	Additional Data Needs	5-25
5.6.6	Screening Summary	5-25
5.7	Alternative 6 - Removal, Treatment, and On-Site Disposal - K-65 Silos	5-25
5.7.1	Description	5-25
	5.7.1.1 System Requirements	5-27
	5.7.1.2 Size and Configuration	5-27
	5.7.1.3 Remediation Time Frame	5-27
	5.7.1.4 Spatial Requirements	5-28
	5.7.1.5 Packaging Requirements	5-28
	5.7.1.6 Wastes Generated	5-28
	5.7.1.7 Permits Required	5-28
5.7.2	Effectiveness	5-28
	5.7.2.1 Protection of Human Health	5-28
	5.7.2.2 Protection of the Environment	5-29
	5.7.2.3 Reduction in Toxicity, Mobility, Volume	5-29
5.7.3	Implementability	5-29
	5.7.3.1 Constructability	5-29
	5.7.3.2 Reliability	5-29

TABLE OF CONTENTS
(Continued)

		PAGE
	5.7.3.3 Maintenance/Operation	5-29
	5.7.3.4 Agency Approvals	5-29
	5.7.3.5 Special Engineering and Equipment	5-30
5.7.4	Cost	5-30
5.7.5	Additional Data Needs	5-30
5.7.6	Screening Summary	5-30
5.8	Alternative 7 - Removal, Treatment, and Off-Site Disposal - Silos 1 and 2 (K-65 Silos)	5-30
5.8.1	Description	5-30
	5.8.1.1 System Requirements	5-32
	5.8.1.2 Size and Configuration	5-32
	5.8.1.3 Remediation Time Frame	5-32
	5.8.1.4 Spatial Requirements	5-32
	5.8.1.5 Packaging/Transportation Requirements	5-33
	5.8.1.6 Wastes Generated	5-33
	5.8.1.7 Permits Required	5-33
5.8.2	Effectiveness	5-33
	5.8.2.1 Protection of Human Health	5-34
	5.8.2.2 Protection of the Environment	5-34
	5.8.2.3 Reduction in Toxicity, Mobility, Volume	5-34
5.8.3	Implementability	5-34
	5.8.3.1 Constructability	5-34
	5.8.3.2 Reliability	5-34
	5.8.3.3 Maintenance/Operation	5-34
	5.8.3.4 Agency Approvals	5-35
	5.8.3.5 Special Engineering and Equipment	5-35
5.8.4	Cost	5-35
5.8.5	Additional Data Needs	5-35
5.8.6	Screening Summary	5-35
5.9	Alternative 8 - Removal, Contaminant Separation, and On-Site Disposal - K-65 Silos	5-35

TABLE OF CONTENTS
(Continued)

		PAGE
5.9.1	Description	5-35
5.9.1.1	System Requirements	5-38
5.9.1.2	Size and Configuration	5-38
5.9.1.3	Remediation Time Frame	5-38
5.9.1.4	Spatial Requirements	5-39
5.9.1.5	Packaging Requirements	5-39
5.9.1.6	Wastes Generated	5-39
5.9.1.7	Permits Required	5-39
5.9.2	Effectiveness	5-39
5.9.2.1	Protection of Human Health	5-39
5.9.2.2	Protection of the Environment	5-40
5.9.2.3	Reduction in Toxicity, Mobility, Volume	5-40
5.9.3	Implementability	5-40
5.9.3.1	Constructability	5-40
5.9.3.2	Reliability	5-40
5.9.3.3	Maintenance/Operation	5-40
5.9.3.4	Agency Approvals	5-40
5.9.3.5	Special Engineering and Equipment	5-40
5.9.4	Cost	5-41
5.9.5	Additional Data Needs	5-41
5.9.6	Screening Summary	5-41
5.10	Alternative 9 - Removal, Contaminant Separation, and Off-Site Disposal - K-65 Silos	5-41
5.10.1	Description	5-41
5.10.1.1	System Requirements	5-41
5.10.1.2	Size and Configuration	5-41
5.10.1.3	Remediation Time Frame	5-43
5.10.1.4	Spatial Requirements	5-43
5.10.1.5	Packaging/Transportation Requirements	5-43
5.10.1.6	Wastes Generated	5-44
5.10.1.7	Permits Required	5-44

TABLE OF CONTENTS
(Continued)

	PAGE
5.10.2 Effectiveness	5-44
5.10.2.1 Protection of Human Health	5-44
5.10.2.2 Protection of the Environment	5-44
5.10.2.3 Reduction in Toxicity, Mobility, Volume	5-45
5.10.3 Implementability	5-45
5.10.3.1 Constructability	5-45
5.10.3.2 Reliability	5-45
5.10.3.3 Maintenance/Operation	5-45
5.10.3.4 Agency Approvals	5-45
5.10.3.5 Special Engineering and Equipment	5-45
5.10.4 Cost	5-46
5.10.5 Additional Data Needs	5-46
5.10.6 Screening Summary	5-46
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

Appendix

LIST OF TABLES

TABLE NO.	TITLE	PAGE
1-1	Waste Characteristics K-65 Silos	1-9
2-1	Remedial Action Alternatives	2-5
6-1	Alternative Evaluation Matrix	6-2
6-2	Cost Estimate for Remedial Action Alternatives	6-3

299

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, West Side of Site	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	General Response Actions	2-3
3-1	Relationship of Screening Criteria to the Nine Evaluation Criteria	3-3
4-1	Conceptual View of Environmental Isolation Enclosure (EIE) Over K-65 Silos	4-2
4-2	Plan View of EIE and Berm Modification	4-3
4-3	Sectional View of EIE, Section A-A	4-4
4-4	Hydraulic Removal of Silo Material	4-6
4-5	Vacuum Removal of Silo Material	4-8
4-6	Water Treatment - Metals Removal, Ion-Exchange and Denitrification	4-13
4-7	Capping Profile	4-15
4-8	Tumulus-Structural Slab	4-16
4-9	Tumulus-Compacted Coarse Sand Base	4-17
4-10	Greater Confinement Disposal Vault Facility (GCD)	4-18
4-11	GCD with Structural Slab and Vault Placed Above Grade	4-19
5-1	Alternative 3 - Removal and On-Site Disposal - Silo 3	5-13
5-2	Alternative 4 - Removal and Off-Site Disposal - Silo 3	5-18
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	5-31
5-5	Alternative 8 - Removal, Contaminant Separation, On-Site Disposal - Silos 1, 2	5-37
5-6	Alternative 9 - Removal, Contaminant Separation, Off-Site Disposal - Silos 1, 2	5-42

14

LIST OF ACRONYMS

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
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
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
NLO	National Lead (Company) of Ohio
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
OAC	Ohio Administrative Code
O&M	Operations and Maintenance
ODNR	Ohio Department of National Resources
OEPA	Ohio Environmental Protection Agency
ORC	Ohio Revised Code
OU4	Operable Unit 4
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SARA	Superfund Amendments and Reauthorization Act

299

LIST OF ACRONYMS

SCO	Surface contaminated object
SDWA	Safe Drinking Water Act
TBC	To be considered
TSCA	Toxic Substances Control Act
UIC	Underground Injection Control
WMCO	Westinghouse Materials Company of Ohio

16

299

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17

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 metal oxide silo) and the potentially contaminated soils surrounding them. This report formally documents the oral presentation of the Initial Screening of Alternatives given to the U.S. Department of Energy (DOE) on June 13, 1989; therefore, it is based upon project and regulatory information available at that time.

REMEDIAL ACTION OBJECTIVES

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

- Control the release of radon gas from wastes
- 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 and identified viable remedial action alternatives based on those technologies. 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 would involve capital costs up to $1 million.

Alternative 1 - Nonremoval, Silo Isolation - Silos 1, 2, 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, grout injection underneath and around the silos, and slurry walls are a few of the technologies considered for this alternative. Silo 3 may receive membrane coatings and/or be cast in concrete before capping as an additional means of isolation.

The estimated capital cost for Alternative 1 is $13 million.

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.

The estimated capital cost for Alternative 2 is $19 million if the wastes are solidified or $24 million if the wastes are 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 estimated capital cost 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 estimated capital cost for Alternative 4 is $9 million if the wastes are transported as low specific activity (LSA) material or $25 million if the wastes are 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 wastes prior to on-site disposal in an engineered disposal facility. This includes silo demolition and disposal of the debris.

The estimated capital cost 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 wastes is identical to Alternative 6 with the exception that the wastes are packaged for shipment to an approved off-site disposal facility.

The estimated capital cost for Alternative 7 is $37 million if the wastes are shipped as LSA material or $42 million if the wastes are shipped as Type B material.

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

This removal alternative for the K-65 wastes 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 estimated capital cost 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 estimated capital cost for Alternative 9 is $27 million with waste being shipped as Type B material. The radioactivity concentration of the separated materials 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 Investigation 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 effectiveness evaluation was determined by these considerations:

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

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

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

The ranges of capital costs (as defined in OSWER Directive 9355.3.-01, page 6-23) 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 technologies and 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 an appendix to this Task 12 Report.

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. At the time of the Task 12 presentation, 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. Chapter 2.0 reviews the development of alternatives as well as the remedial action objectives and general response actions. Chapter 3.0 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, Chapter 3.0 also discusses treatment and on-site/off-site disposal considerations. Chapter 4.0 will discuss the refinement of technologies that has occurred since the previous task. Chapter 5.0 will present the refinement and evaluation of the alternatives as they are rated against the evaluation criteria. Chapter 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). 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) and the Superfund Amendments and Reauthorization Act (SARA) 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 K-65 silos have been

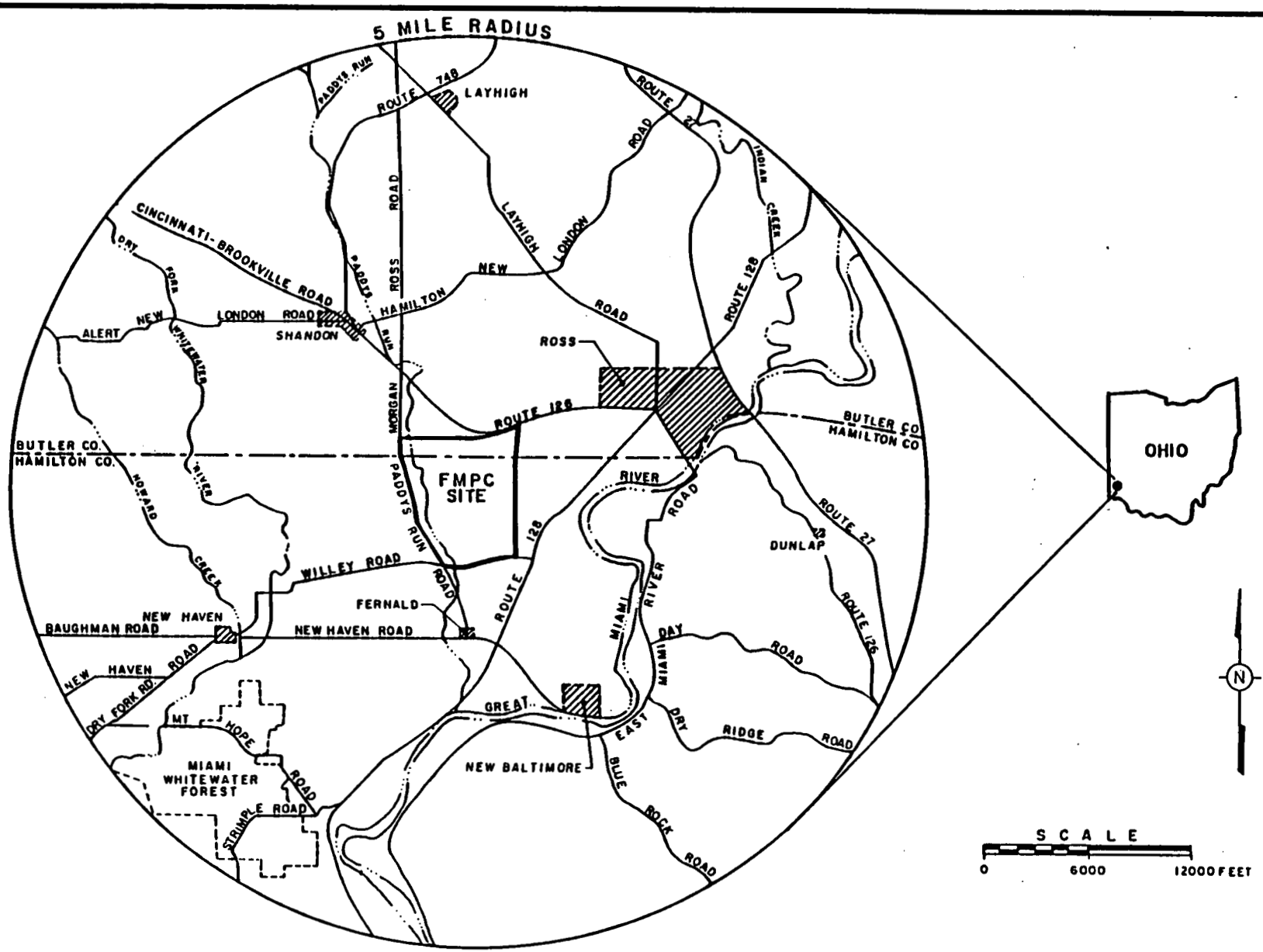

FIGURE 1-1. 5 MILE RADIUS MAP, FEED MATERIALS PRODUCTION CENTER

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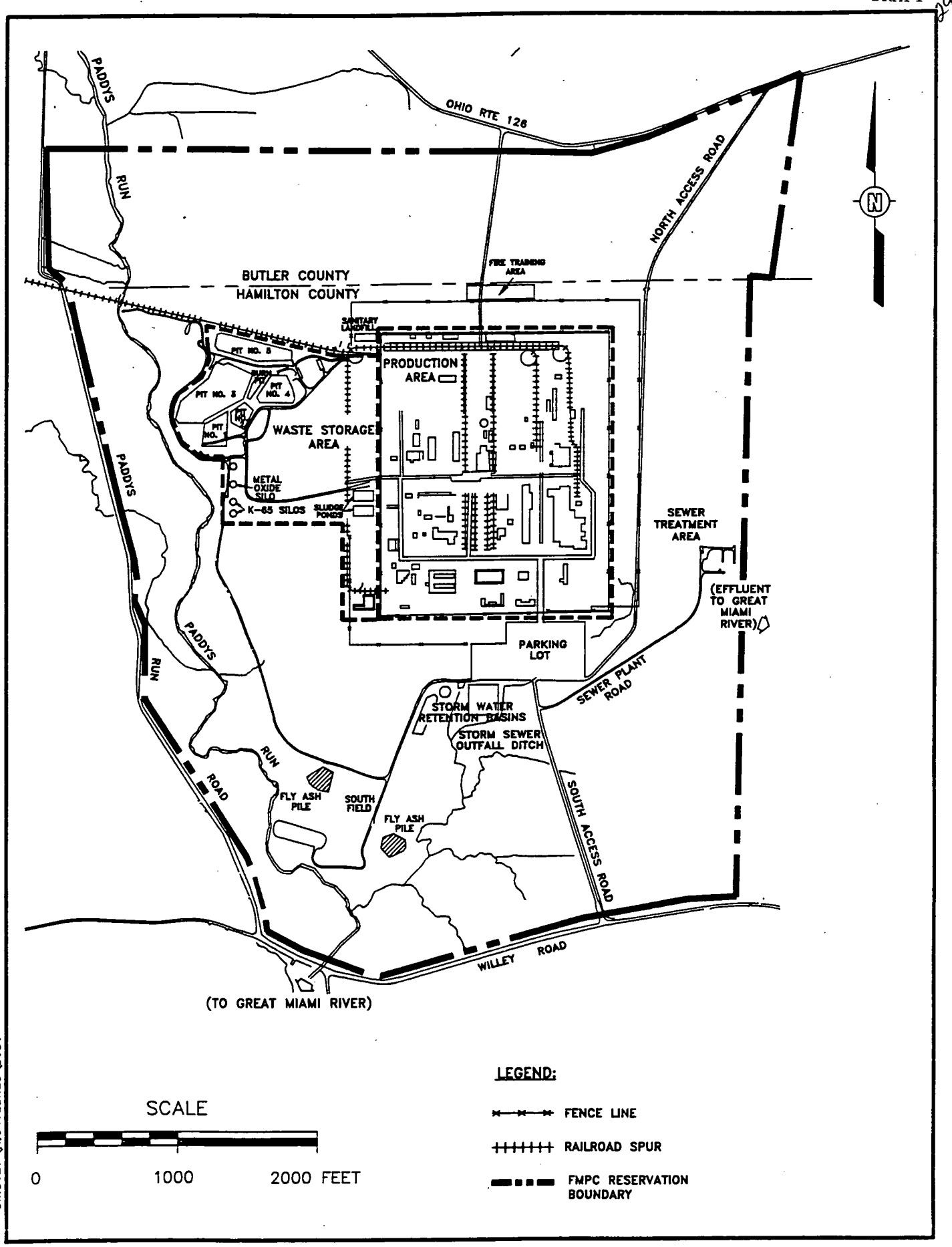

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FIGURE 1-2. MAJOR FEATURES OF THE FEED MATERIALS PRODUCTION CENTER

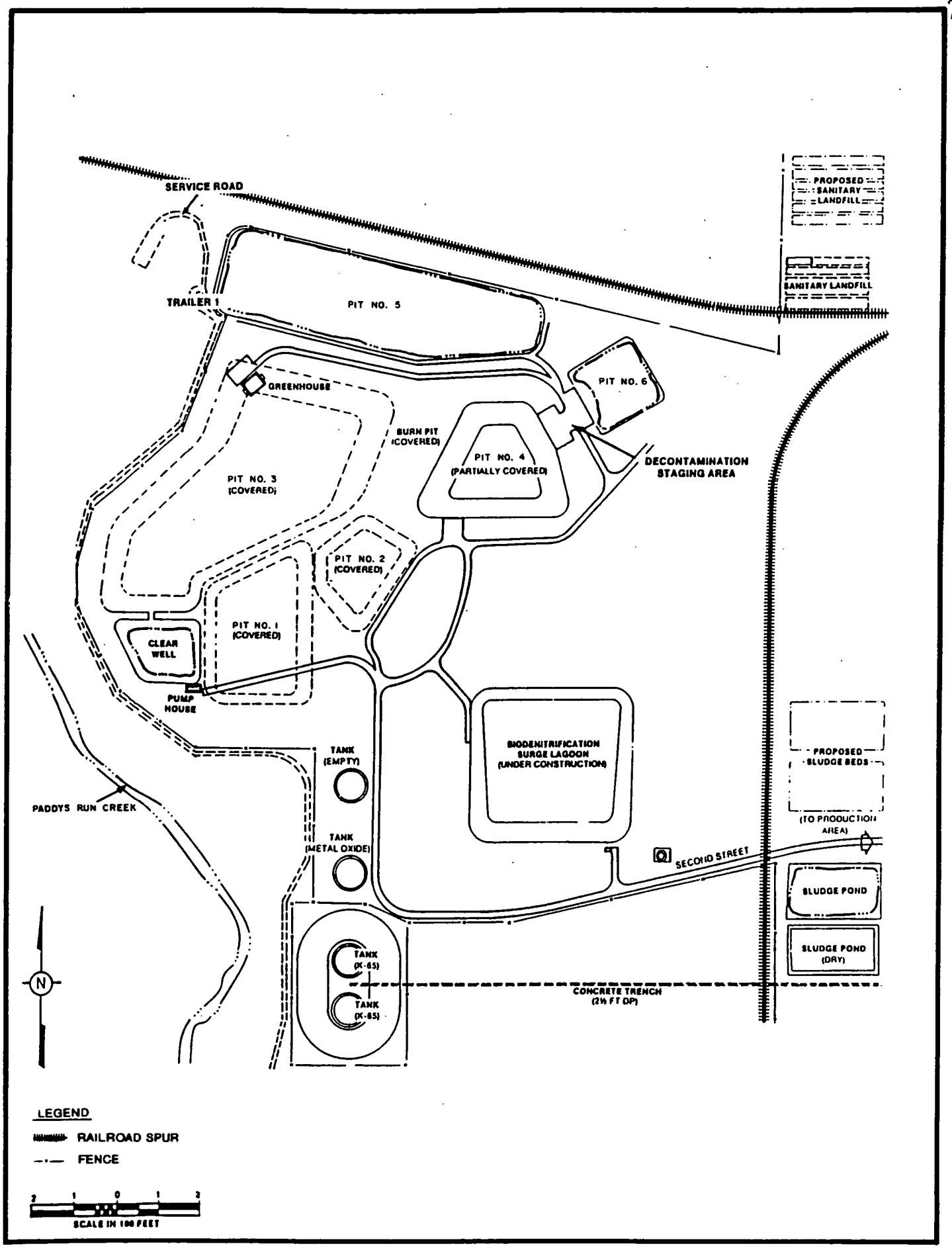

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FIGURE 1-3. WASTE STORAGE AREA WEST SIDE OF SITE

coated with 0.75 inches of gunite and are surrounded by an earthen berm to a height of approximately 26 feet, while the metal oxide silo 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 percent U-235), and a presently undetermined amount of thorium (Th-230). The majority of the waste material is silica and metallic compounds. Table 1-1 lists the K-65 silo constituents and their approximate quantities, based on past sampling efforts. Documentation of the past sampling efforts are included in the reference section.

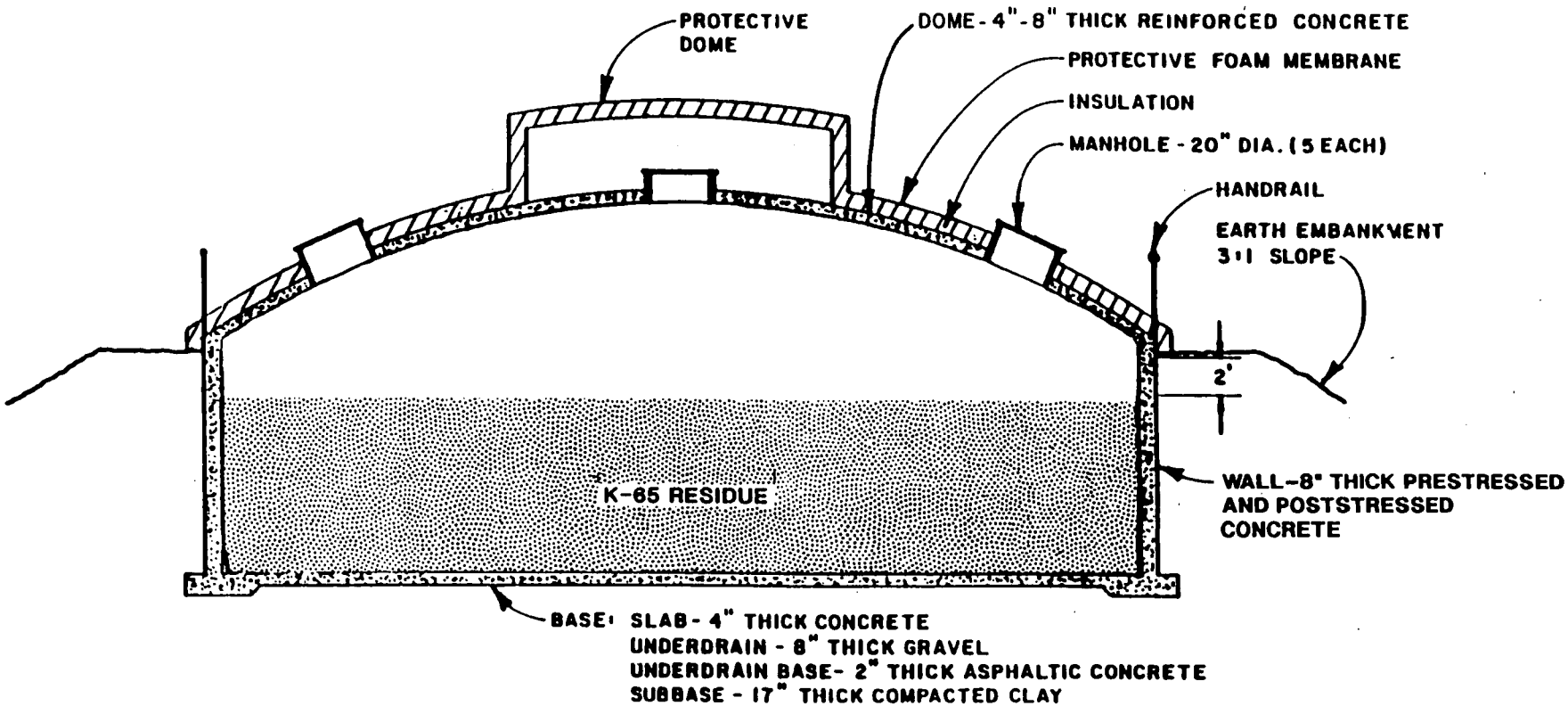

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FIGURE 1-4. TYPICAL CROSS-SECTION THROUGH SILOS 1 AND 2

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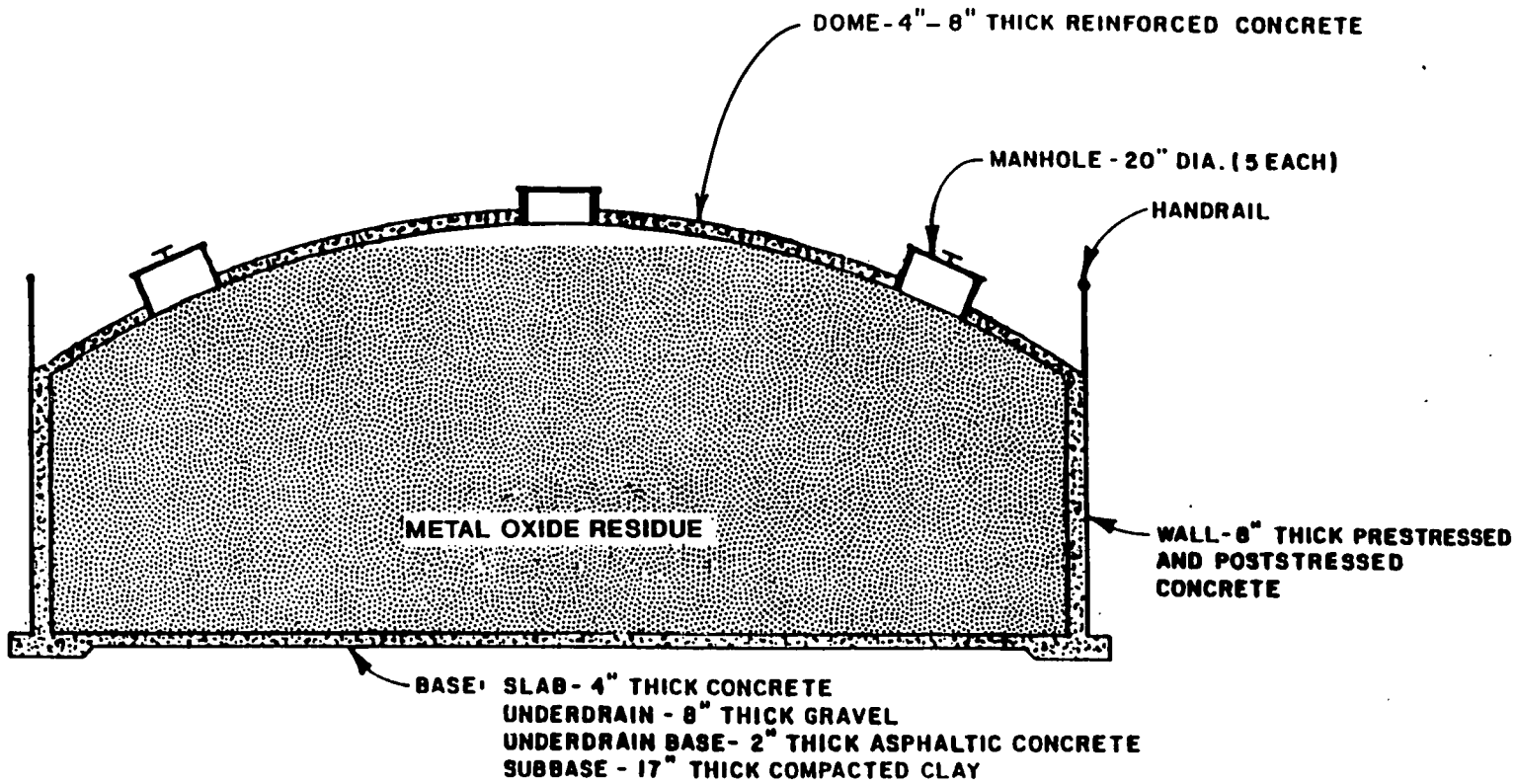

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FIGURE 1-5. CROSS-SECTION THROUGH SILO 3

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TABLE 1-1

WASTE CHARACTERISTICS, K-65 SILOS

	Reported Values		
Characteristic	Litz[a]	NLO[b]	Vitro[c]
Dry wt, kg (tons)	-	8.79×10^6 (9690)	1.59×10^6
Estimated volume	-	5,522 (195,000)	3,155
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.

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 percent U-235), an undetermined amount of 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 wastes (dry and powdery), is not believed to be the source of any contaminant migration to the surrounding and underlying environs. Subsequent to the time of the Task 12 oral presentation in June 1989, samples have been taken and are under analysis.

2.0 DEVELOPMENT OF ALTERNATIVES

2.1 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 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 eliminated from further consideration any remedial action alternative that would have relied on that technology.

2.1.1 Remedial Action Objectives

Operable Unit 4 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:

- Prevent the release of radon gas from wastes
- Prevent the migration of contaminants to environmental media that would exceed public health or environmental standards
- Prevent 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 full removal or containment of the source.

2.1.2 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 response actions for Operable Unit 4 are shown in Figure 2-1.

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). It 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 LDR).

2.1.3 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, grouting, 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 wastes 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,

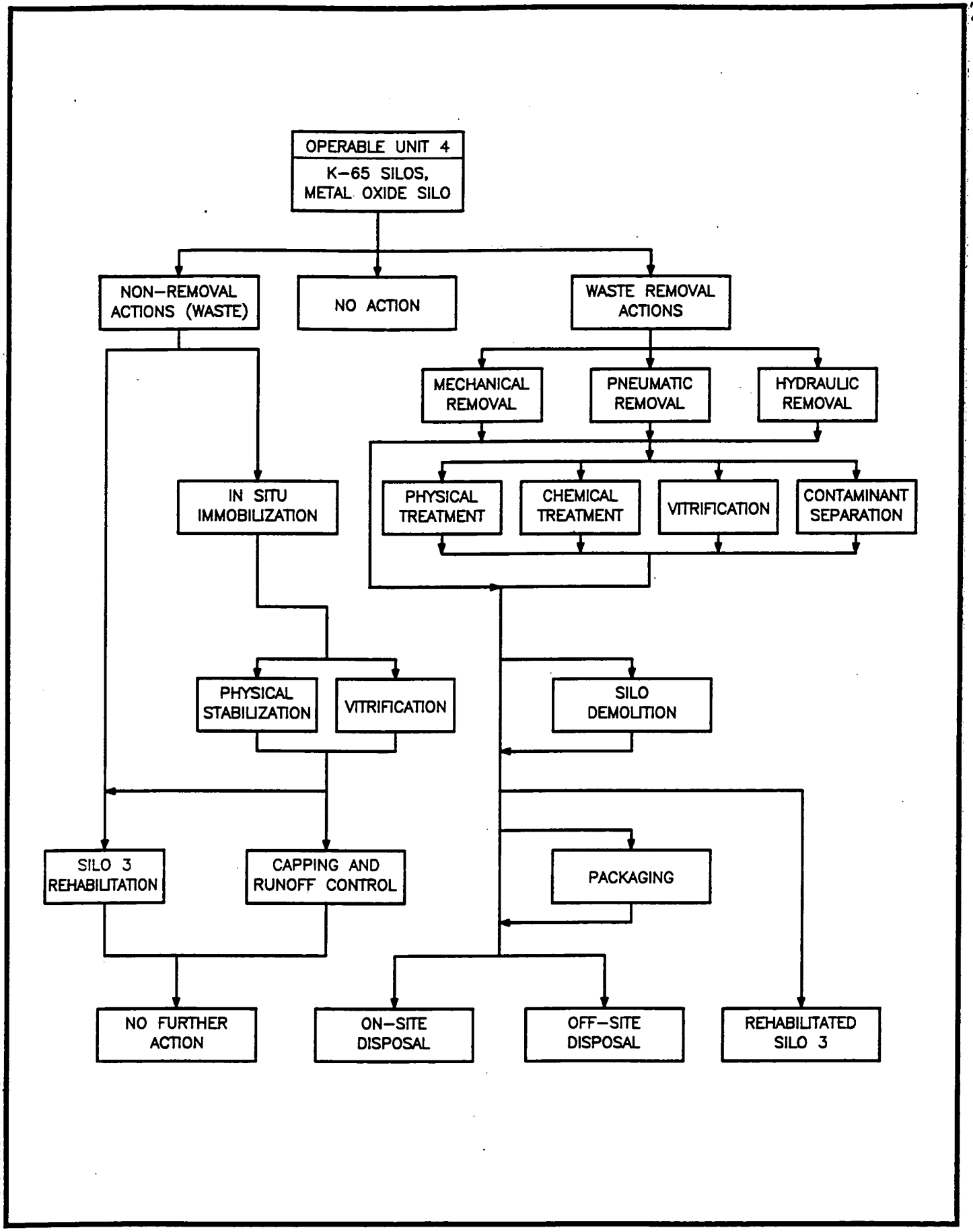

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FIGURE 2-1. GENERAL RESPONSE ACTIONS

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.

2.2 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 the metal oxide silo. 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 2-1 and in the following sections.

2.2.1 Alternative 0 - No Action

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

2.2.2 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, grout underneath and around the silos, and slurry walls as considered technologies for this alternative. Silo 3 may receive membrane coatings and/or be cast in concrete before capping as an additional means of isolation.

2.2.3 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 2-1
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		X	
Off-Site Disposal					X			X		X

2.2.4 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 also includes silo demolition and disposal of the debris.

2.2.5 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 that the waste is packaged for shipment to an approved off-site disposal facility.

2.2.6 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 wastes will be permanently stored in either Silo 3 or Silo 4 following its rehabilitation. Following final disposition of the wastes, a berm and a cap will be installed.

2.2.7 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 wastes prior to on-site disposal in an engineered disposal facility. This also includes silo demolition and disposal of the debris.

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

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

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

This removal alternative for the K-65 wastes 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 stabilization or vitrification prior to on-site disposal. This alternative also includes silo demolition and disposal of the debris.

2.2.10 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.

3.0 ALTERNATIVE SCREENING METHODOLOGY

3.1 INTRODUCTION

Operable Unit 4 remedial action alternatives developed in the previous task had been assembled by combining 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.

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

3.2 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.

3.3 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 Figure 3-1.

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.

Chapter 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. Chapter 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.

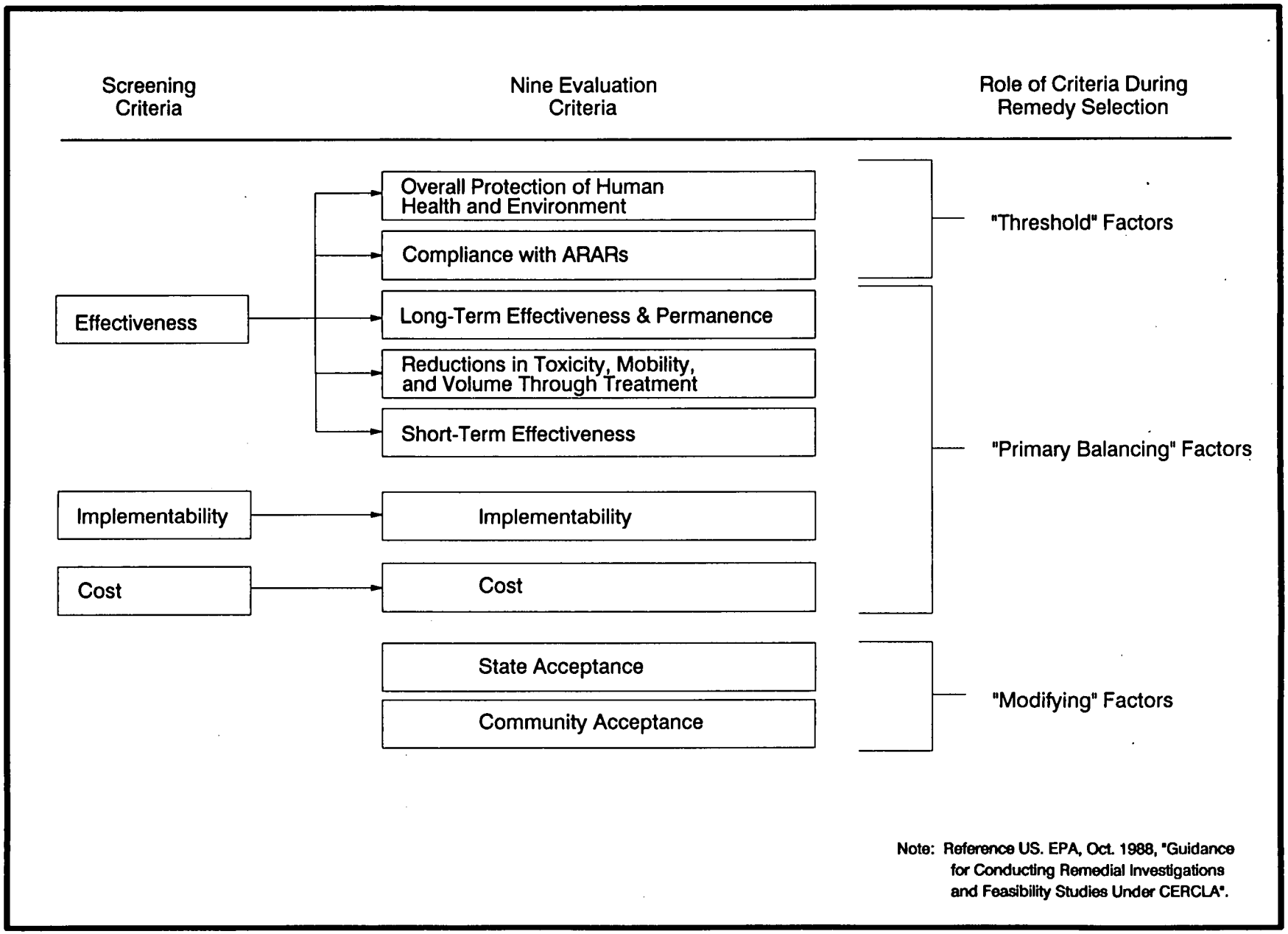

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FIGURE 3-1. RELATIONSHIP OF SCREENING CRITERIA TO THE NINE EVALUATION CRITERIA

3.3.1 Effectiveness Evaluation

A key aspect of the screening evaluation is the effectiveness of an alternative in protecting human health and the environment. In 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. 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.

3.3.2 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. 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.

3.3.3 Cost Evaluation

Cost estimates were prepared for each alternative to allow a comparison of costs among similar alternatives. 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 present 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.

3.3.4 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 significant advantages in performance or implementability.

3.4 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 wastes. 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.

3.5 WASTE DISPOSAL CONSIDERATIONS

Evaluating the off-site versus on-site disposal issue for the silo wastes 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. Land Disposal Restrictions (LDR) impacts on disposal alternatives are discussed in this section.

3.5.1 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 presently being considered is the Nevada Test Site (NTS). NTS is superior to Fernald in terms of demographics, meteorology, hydrology, and security. Additionally, long-term management, monitoring, and maintenance are already committed at NTS regardless of the presence of the silo wastes. Whereas the silo wastes will be an inconsequential part of the total wastes buried at NTS, they will constitute a significant portion of the total radioactivity at Fernald should they remain on site.

3.5.2 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 of the on-site disposal option will be reduced.

3.5.3 Reduction in Toxicity, Mobility, and Volume

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.

3.5.4 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.

3.5.5 Cost

The least costly capital expenditure 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 capital costs for the latter are substantially lower.

When considering the O&M costs associated with institutional control (100 years per 10CFR61), 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 wastes. The annual O&M costs to maintain a disposal facility at Fernald, however, will be significant.

3.5.6 Overall Protection of Human Health and the Environment

The on-site disposal option may require a superior prior 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 wastes to an off-site disposal area, however, presents a risk that must also be considered. Shipment of the wastes 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 from Las Vegas to NTS could be constructed for this purpose, it could be used by other federal facilities in the future.

3.5.7 Land Disposal Restrictions

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

4.0 TECHNOLOGY 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 which allows an effective evaluation and screening of alternatives. These technologies, in addition to those which were sufficiently developed in the previous task, are described in the following sections before alternative evaluation and screening.

4.1 ENVIRONMENTAL ISOLATION ENCLOSURE

Prior to initiating any waste removal or in situ waste treatment alternatives, an environmental isolation enclosure (EIE) would be constructed to enclose the K-65 silos and/or Silo 3 and the surrounding work area (Figure 4-1). The purpose of the enclosed facility will be 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. Each design would incorporate equipment and manway airlocks as well as a remote-controlled bridge crane system over the silos. All exhausted air from the EIE would be filtered to meet site-specific discharge limits.

The EIE would be required only for as long as required to support remediation efforts. The facility would 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 would require the following:

- Silo berm modifications (Figures 4-2 and 4-3)
- Utility and general construction/remediation support services at both interior and exterior work staging areas
- EIE foundation
- Bridge crane system (Figures 4-1 and 4-3), 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

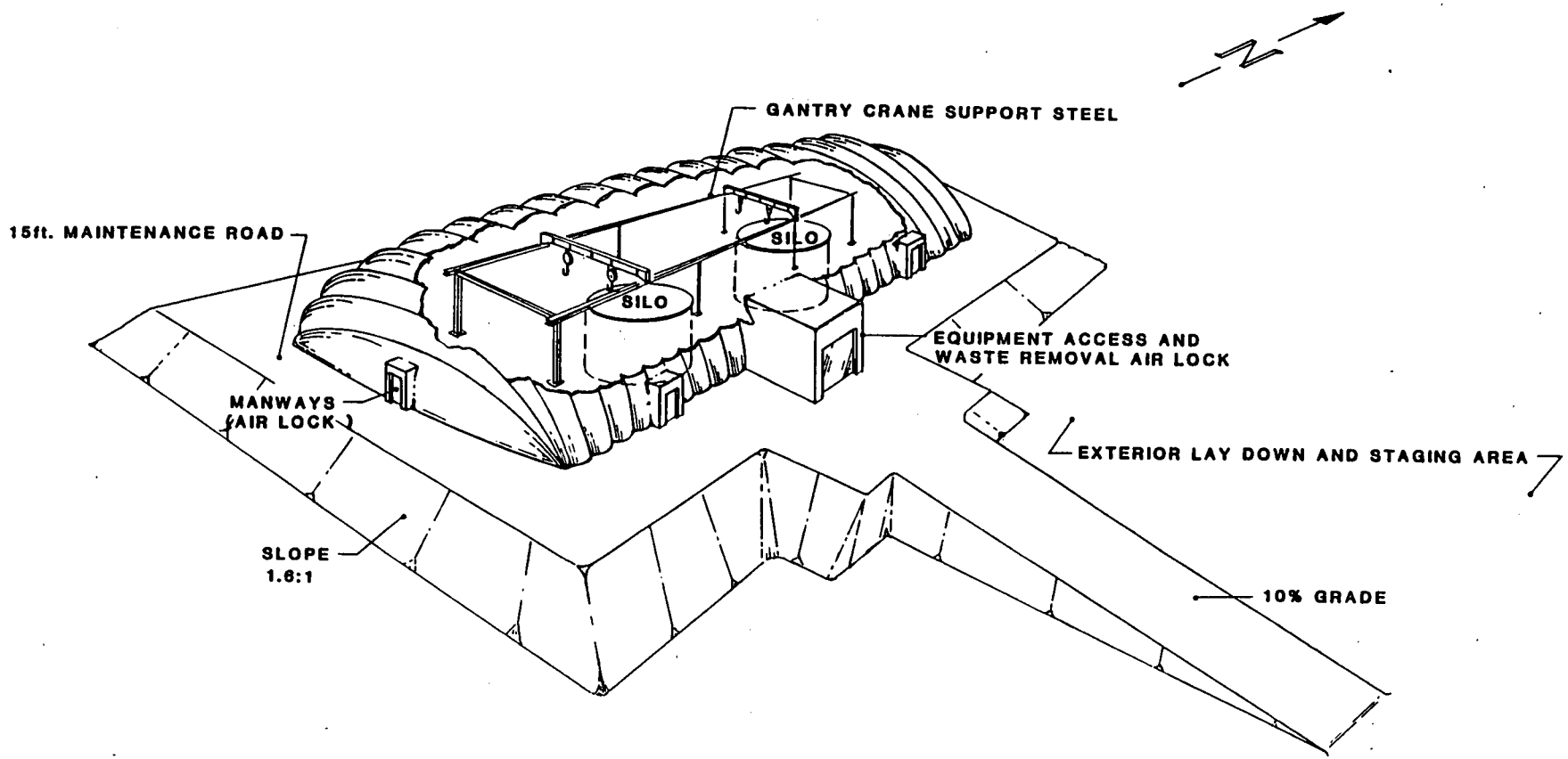

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FIGURE 4-1. CONCEPTUAL VIEW OF ENVIRONMENTAL ISOLATION ENCLOSURE (EIE) OVER K-65 SILOS

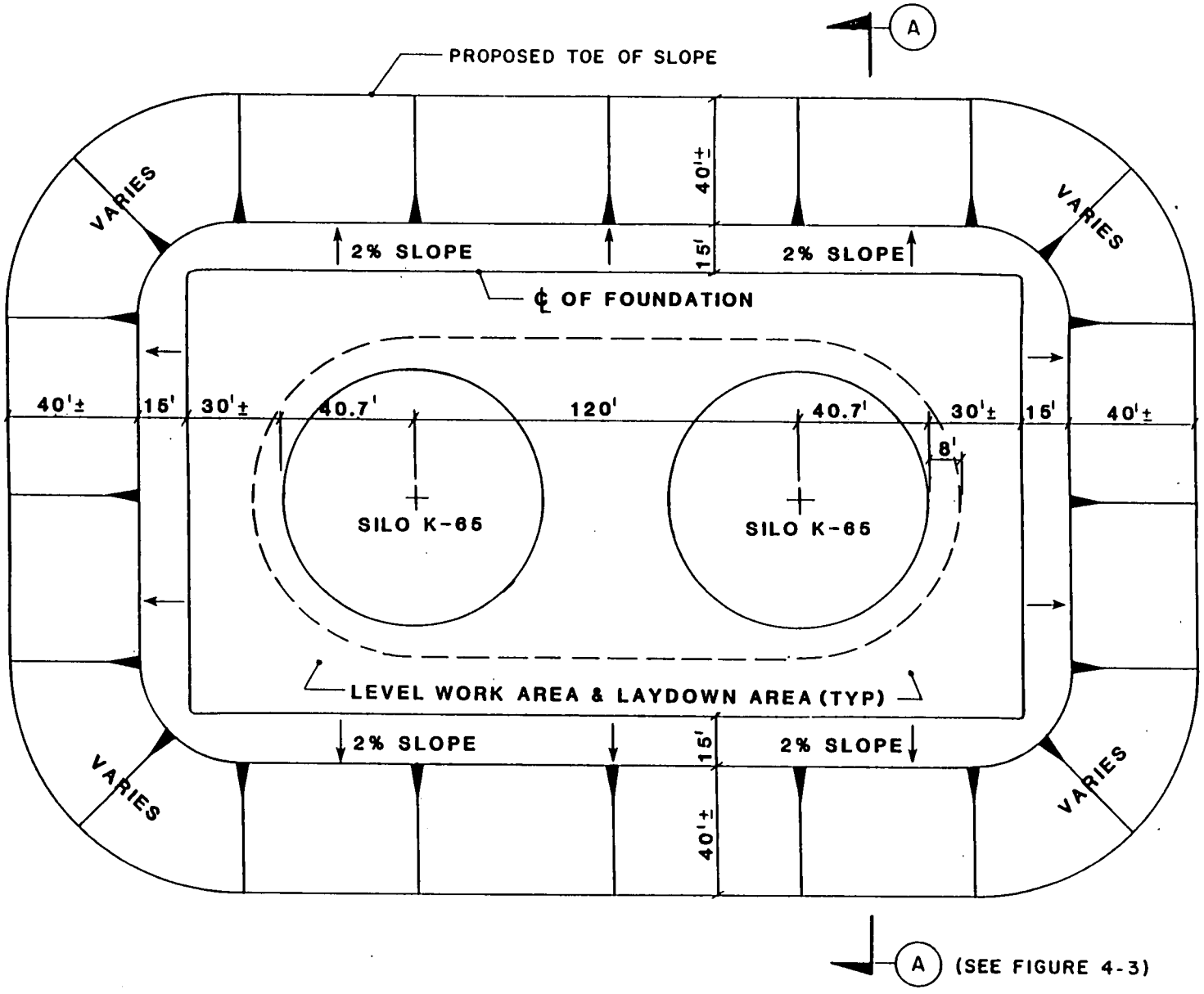

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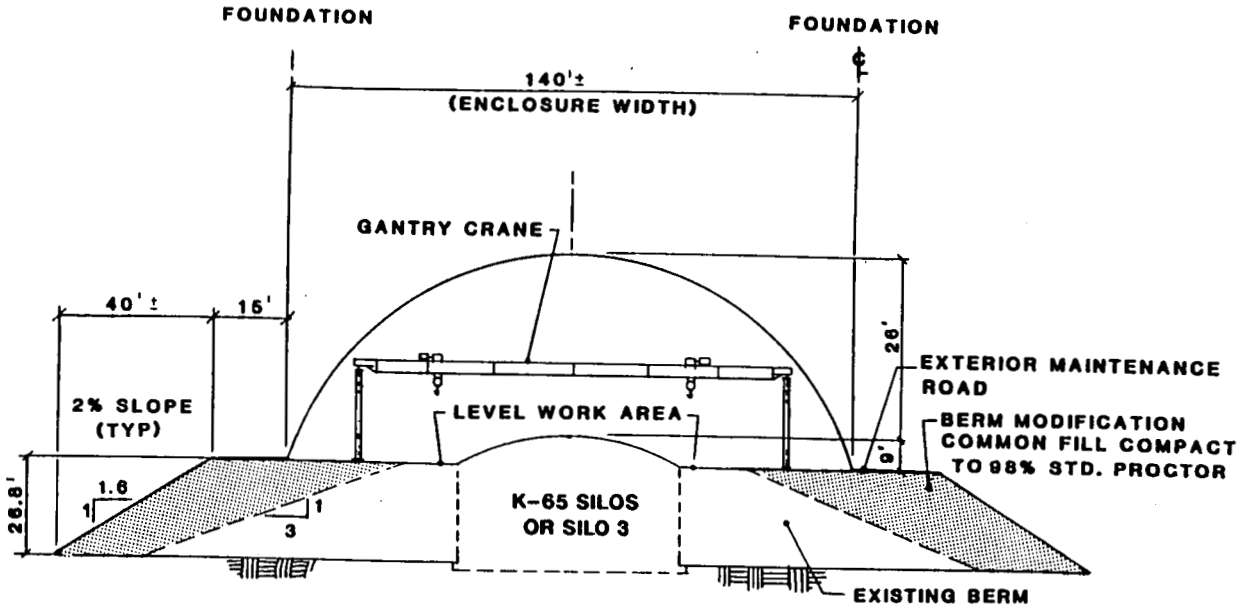
FIGURE 4-2. PLAN VIEW OF EIE AND BERM MODIFICATION



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

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FIGURE 4-3. SECTIONAL VIEW OF EIE, SECTION A-A

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

- Installation of HVAC system
  - High efficiency particulate air (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.

4.2 MECHANICAL, HYDRAULIC, PNEUMATIC REMOVAL

4.2.1 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 that would be required are:

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

4.2.2 Hydraulic Removal

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

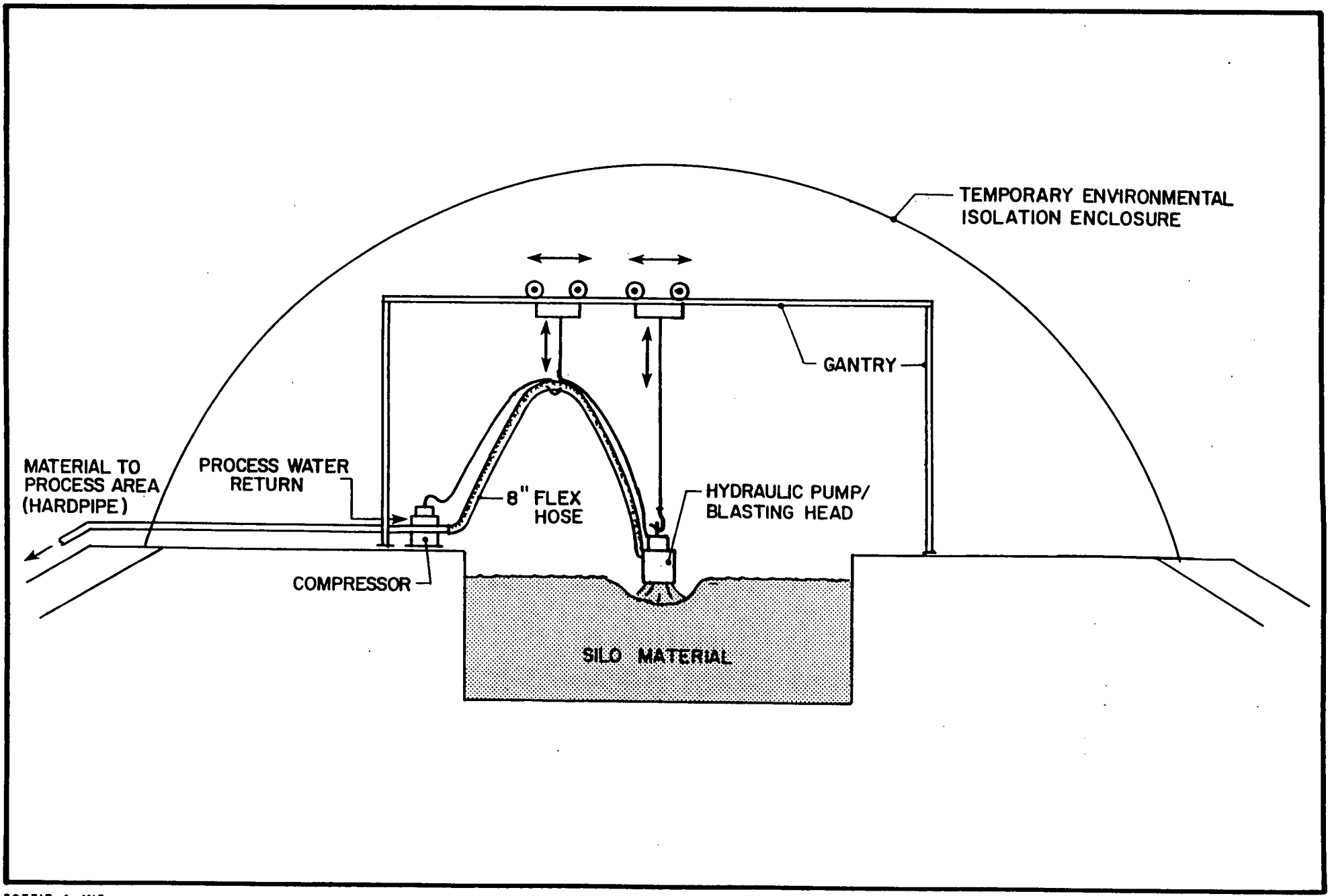

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FIGURE 4-4. HYDRAULIC REMOVAL OF SILO MATERIAL

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

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

4.2.3 Pneumatic Removal

The pneumatic removal method would involve the use of a mechanical cutter and an airlift to entrain the material in an airstream which would be routed to a temporary storage system for separation of solids (Figure 4-5). This separation scheme would utilize filters, cyclone separators, and dust collectors, among other devices. The waste would then be routed to a packaging facility and the filtered air will be recycled to the removal system or discharged. All operations would be conducted in closed vessels and all vents would be equipped with HEPA filters and carbon adsorbers (if necessary) for emission control. The major pieces of equipment that would be required are:

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

4.3 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. The steel wire and rebar would require cutting 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.

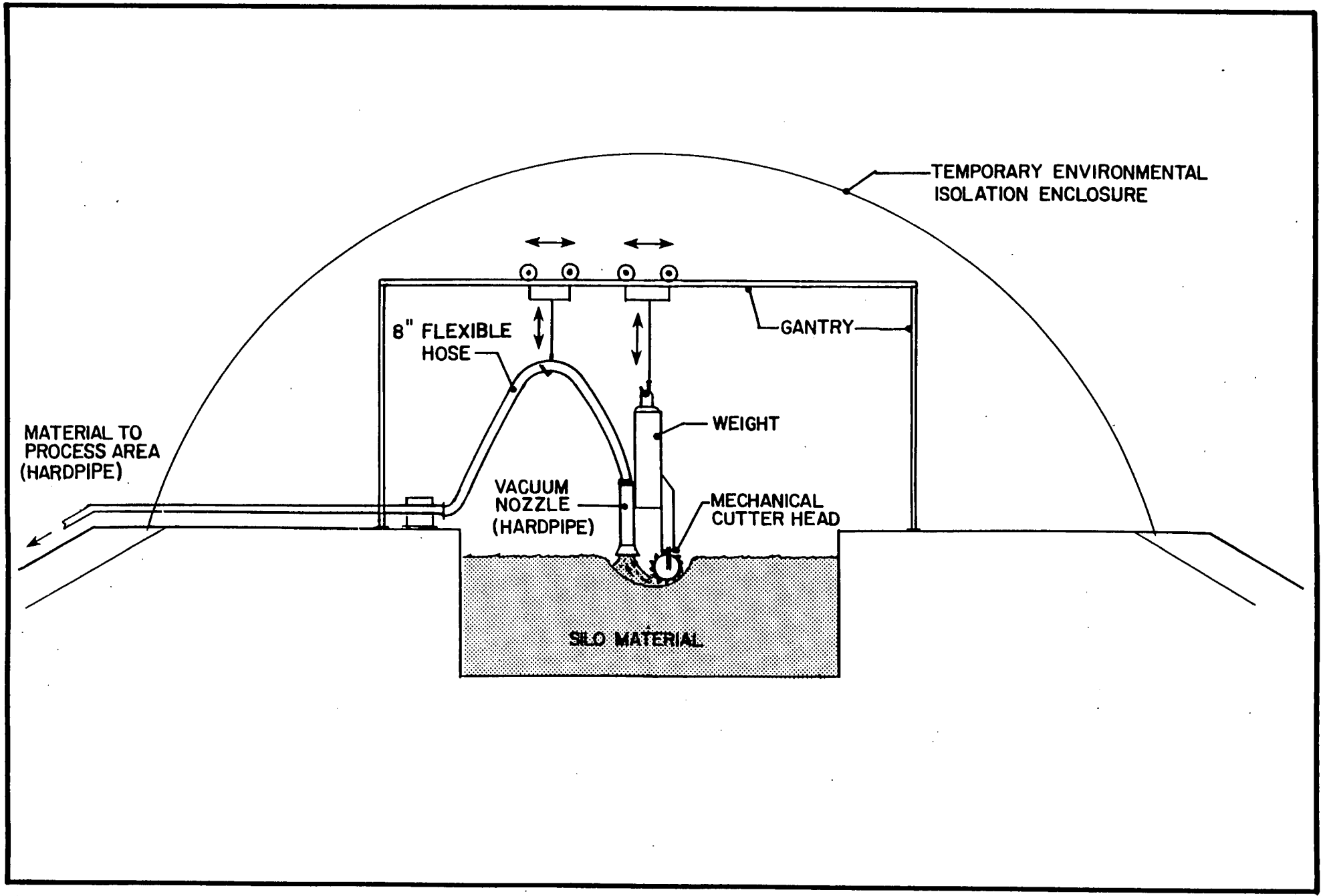

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FIGURE 4-5. VACUUM REMOVAL OF SILO MATERIAL

- 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 will 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. The reinforced steel will require cutting with a torch. This method 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) could 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 would be used inside an Environmental Isolation Enclosure (EIE), with the exception of the headache ball and the explosive charges. Concerns about dust could be eliminated if demolition were to occur inside such a structure. Other features such as underground piping and tanks would require removal in addition to the silo. If an off-site disposal alternative is selected, the concrete rubble and piping would have to 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.

4.4 STABILIZATION/VITRIFICATION

4.4.1 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 would be 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 would be conveyed to a mixer or pug mill where it will be mixed with water, the proprietary reagents, and activated carbon. The waste would then be poured into high integrity containers (HIC) or bags for curing before disposal into the disposal facility.

- Stabilization with polymerized organic monomers:
  - For this process option the waste would be mixed in a drum or HIC with a monomer and an initiating agent or catalyst prior to deposition in 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.

4.4.2 Vitrification

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

The dried wastes would be conveyed to the vitrification system surge hopper. The vitrification rate would be approximately 50 to 100 tons per day so the surge hopper would be sized for approximately 100 tons of waste. All equipment would 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 would be electrically heated and designed for minimum emissions of radon, dust, and volatile metals. The glass from the melter would be cast into steel containers similar to LSA boxes (4- to 6-foot-cubes). The steel containers would be cooled by air and water during casting, and after cooling the boxes would be sealed and placed in the disposal facility.

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

4.5 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 would 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 wastes, 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 would 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.

4.6 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 sent to sludge treatment.

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 back to the precipitation unit. Other resins are used one time 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 water for discharge, and a biological sludge that can be disposed of as part of WMCO's ongoing waste operations program.

Figure 4-6 presents a flow diagram for water treatment.

4.7 IMPERMEABLE CAP

Capping involves the installation of a barrier over the surface of the 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, 40CFR61, and 10CFR61. Some of the considerations are:

- Minimum liquid migration through the wastes
- 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.

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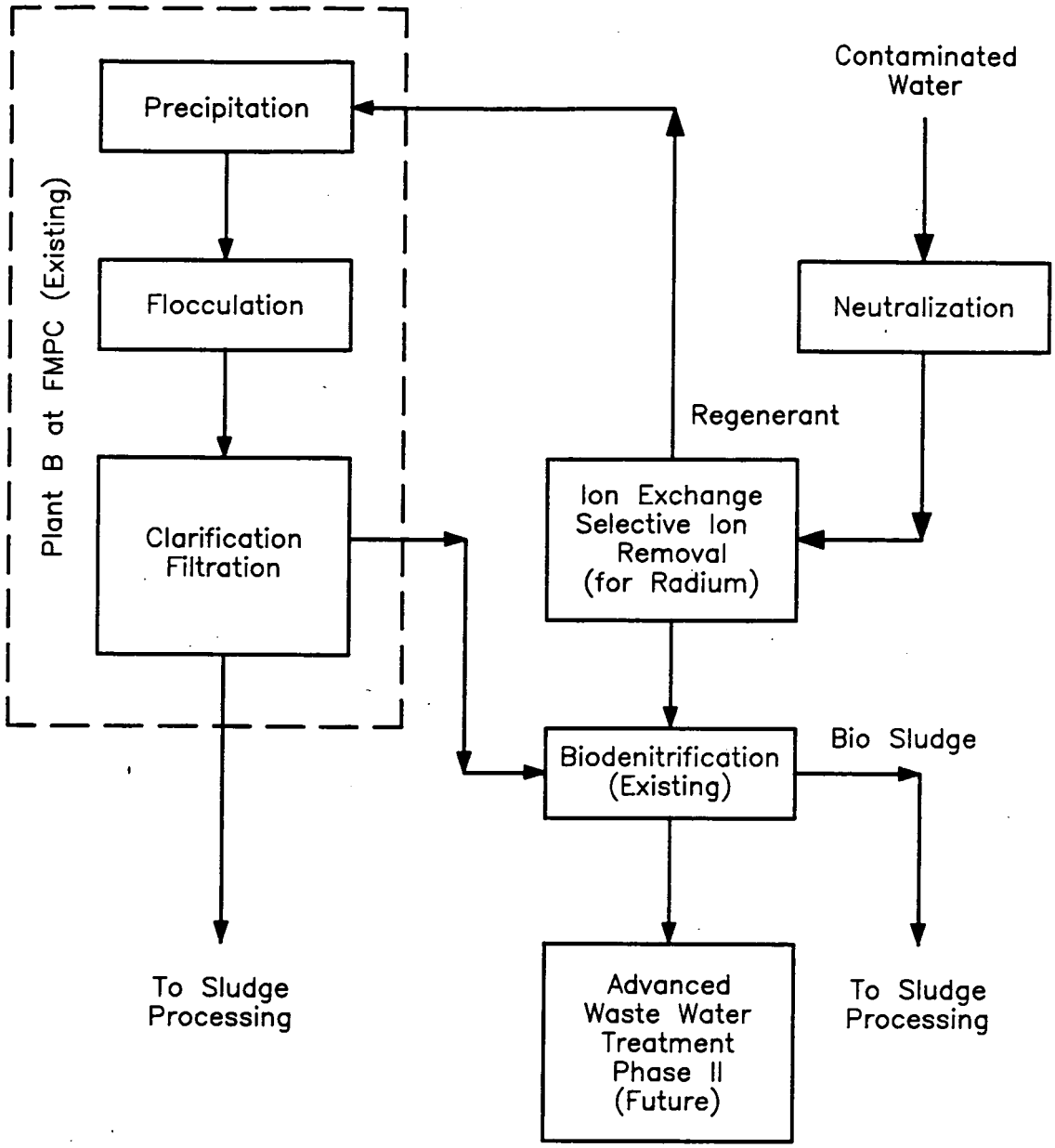

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FIGURE 4-6. WATER TREATMENT - METALS REMOVAL, ION-EXCHANGE AND DENITRIFICATION

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

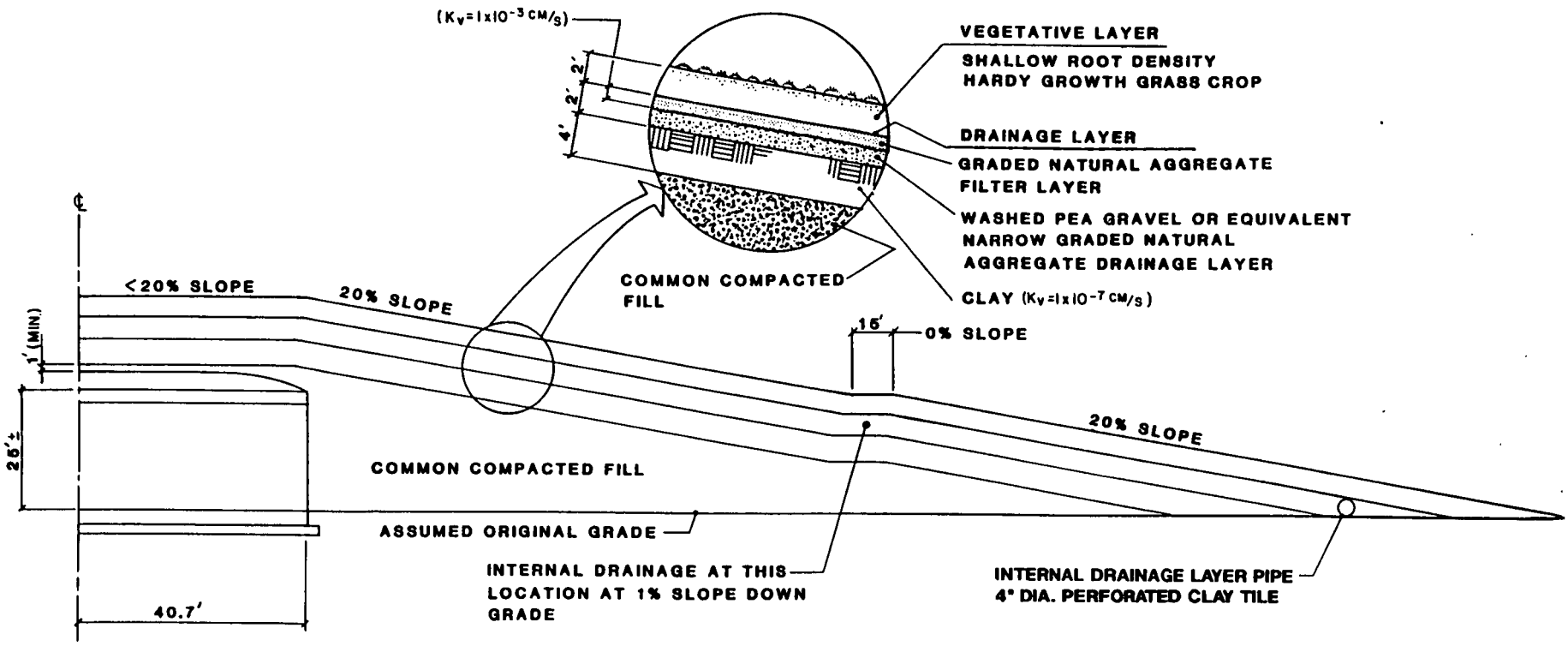
- An upper vegetative layer
- A drainage layer
- A low permeability bottom layer

The vegetative layer would be supported by the topsoil/cover. The drainage layer would consist of sand, and the low permeability layer would consist of a layer of clay with a permeability of less than 1×10^{-7} cm/sec. This design would divert infiltrating liquids away from the enclosed waste materials (Figure 4-7).

4.8 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 will accept only containerized and highly solidified waste forms. Two design options are being considered for each (Figures 4-8 through 4-11):

- 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



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

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FIGURE 4-7. CAPPING PROFILE

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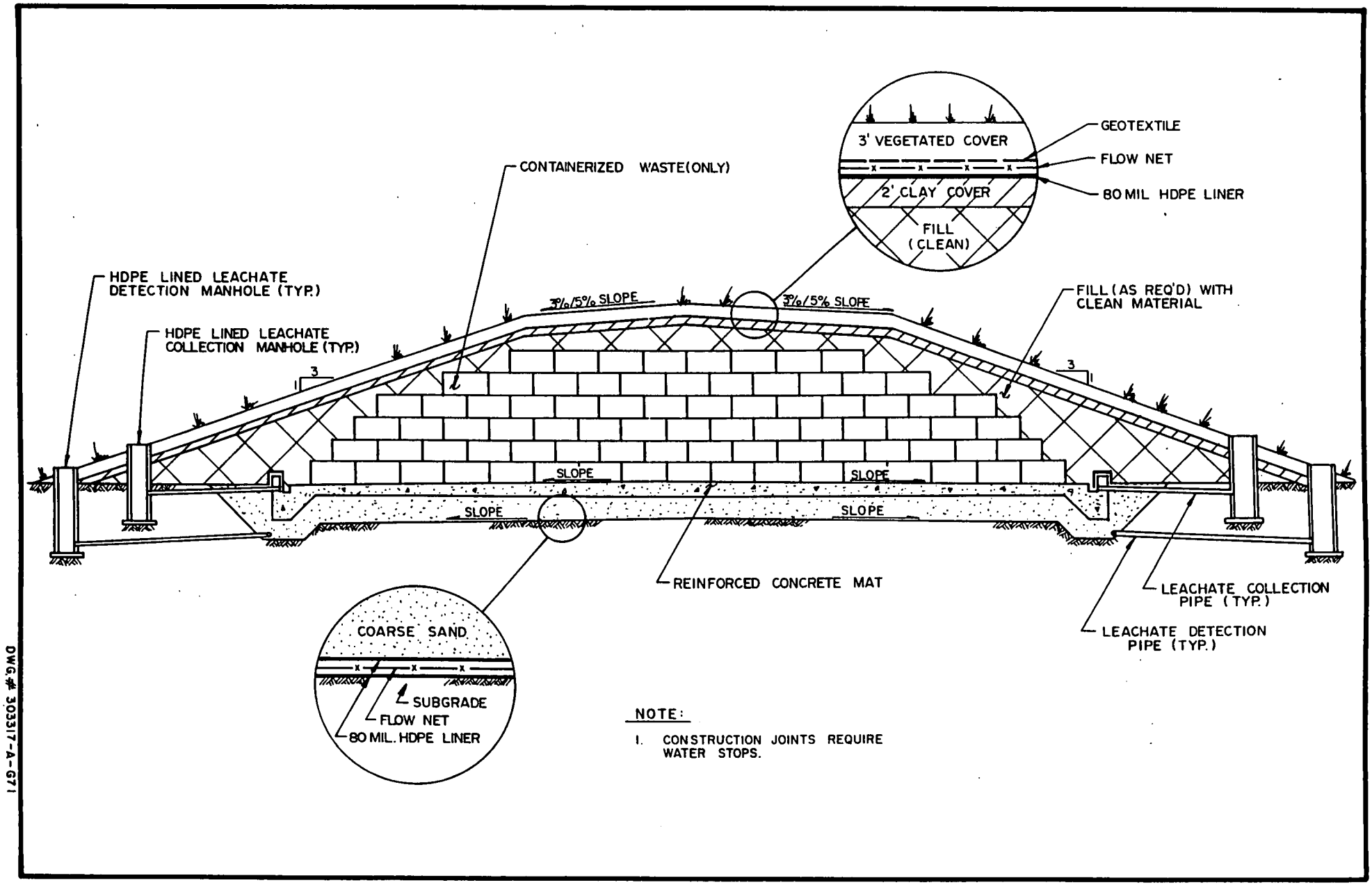

FIGURE 4-8. TUMULUS-STRUCTURAL SLAB

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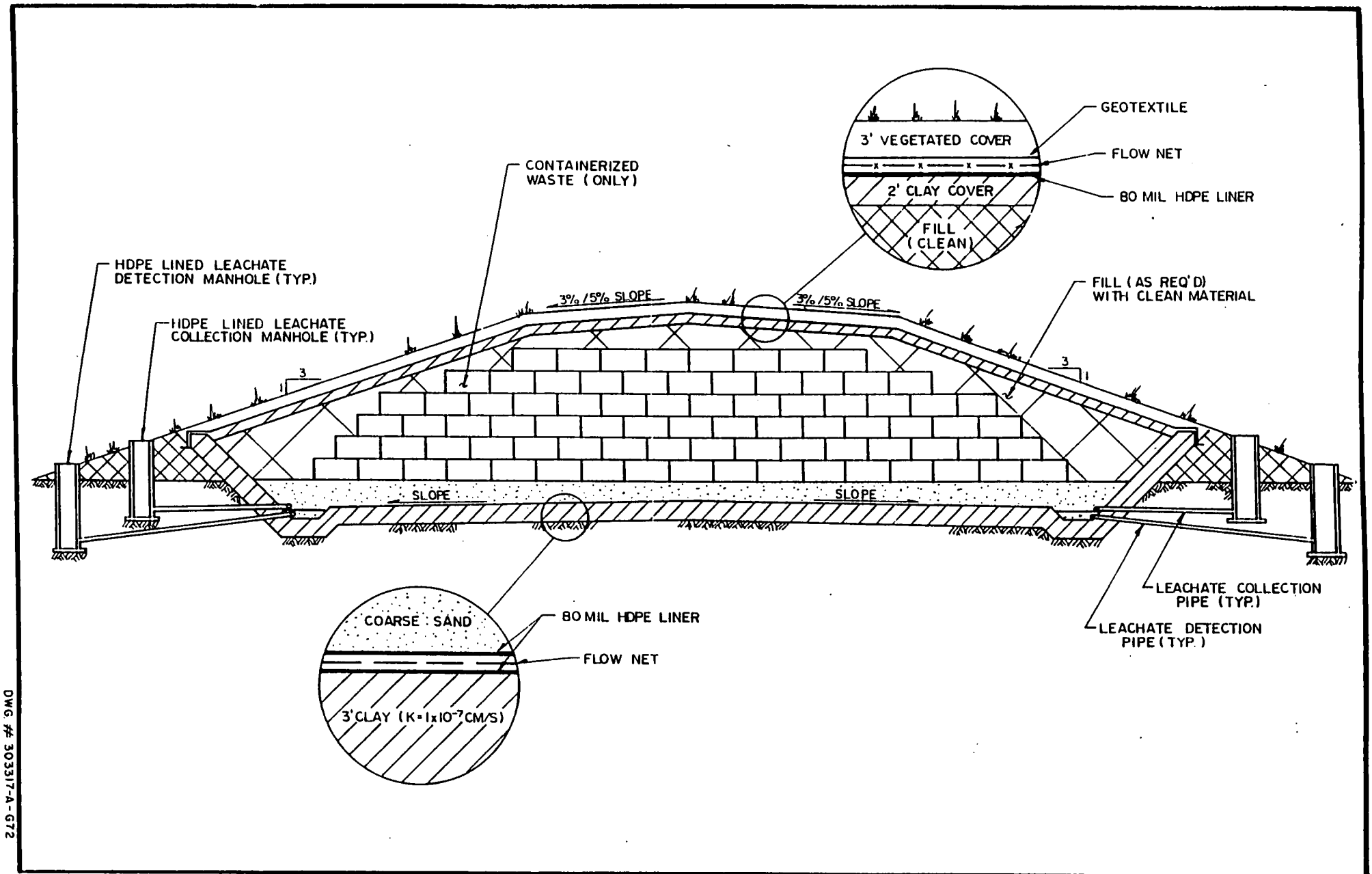

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FIGURE 4-9. TUMULUS-COMPACTED COARSE SAND BASE

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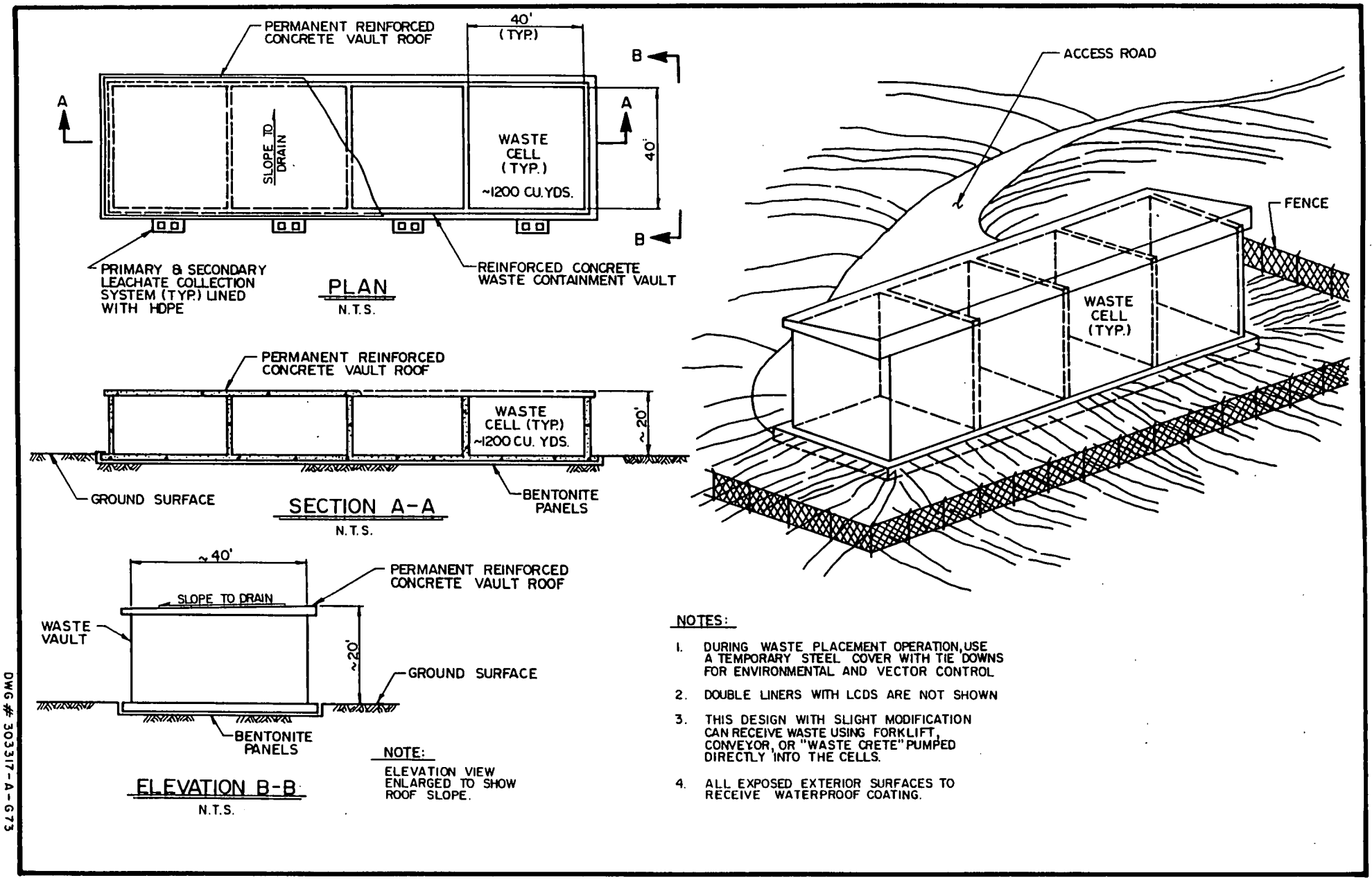

FIGURE 4-10. GREATER CONFINEMENT DISPOSAL VAULT FACILITY (GCD)

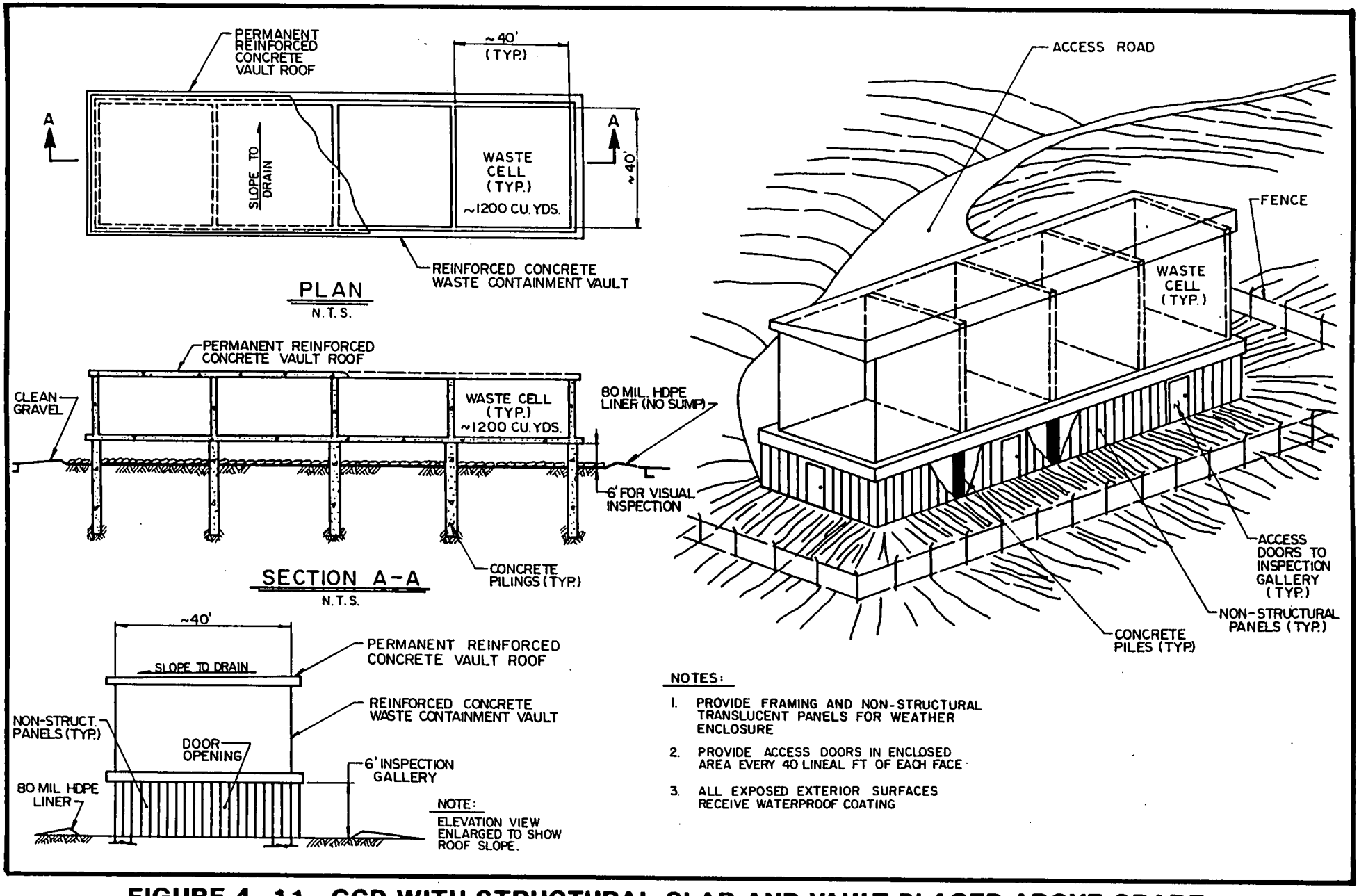

FIGURE 4-11. GCD WITH STRUCTURAL SLAB AND VAULT PLACED ABOVE GRADE

4.9 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 shipping designations allowed in the DOT regulations, there are four which apply to the K-65 silos' and metal oxide 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 silos' and metal oxide residues will be specified as "normal form" because they have not been tested to meet the requirements of 49CFR173.469.

4.9.1 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 silos' and metal oxide 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 wastes, it would require well over a billion packages to ship the wastes. The logistics of inventorying and accounting for this number of packages alone renders this shipping classification unsuitable for the shipping of the silo wastes.

4.9.2 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 wastes. The waste material may meet the definition of 49CFR173.403(n)(1) 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 will have to meet the restrictions of 49CFR173.403(n)(4) 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) 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.

4.9.3 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 and .412 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 wastes are estimated to require over one million packages. As in the Limited Quantities discussion, the logistics for storing and accounting for this large quantity of packages would be prohibitive.

4.9.4 Type B

Type B packaging is required for all wastes which exceed Type A packaging requirements. 49CFR173.411 and 10CFR71.51 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 wastes can be shipped in Type B containers.

5.0 SCREENING OF ALTERNATIVES

The alternatives will be further refined and evaluated per the methodology defined in Chapter 3.0 of this report. These refined alternatives incorporate the technologies discussed in Chapter 4.0. The results of the alternative evaluation will be used to conduct the ranking of alternatives in Chapter 6.0.

5.1 ALTERNATIVE 0 - NO ACTION

This alternative is the no action alternative.

5.1.1 Description

In this alternative the silo wastes will remain as they are without the implementation of any removal, treatment, containment, or mitigating technologies. Other than the installation of monitoring equipment, no actions are taken in this alternative.

5.1.1.1 System Requirements

This alternative will require:

- Groundwater monitoring stations
- Air monitors for radioactivity
- Area radiation monitors

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 is needed. The space taken by monitoring equipment can be within the existing silo area and will be insignificant.

5.1.1.5 Packaging Requirements

None.

5.1.1.6 Wastes Generated

No new wastes will be generated.

5.1.1.7 Permits Required

None.

5.1.2 Effectiveness

5.1.2.1 Protection of Human Health

Short- and long-term protection of public health is 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 are poor for the reasons cited above.

5.1.2.3 Reduction in Toxicity, Mobility, and Volume

No reduction in any of these characteristics occurs in this alternative, so it is rated poor.

5.1.3 Implementability

5.1.3.1 Constructability

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

5.1.3.2 Reliability

This alternative is below average in reliability. Although the minor work of monitor installation can 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, and no other upkeep is within its scope.

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 are routine.

5.1.4 Cost

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

5.1.5 Additional Data Needs

None.

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 is the most cost effective (i.e., no capital costs), 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 wastes 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 as follows:

- K-65 Silos:
  - Grout injection around and underneath silos
  - Slurry wall around silos
  - Filling of silo void space
  - Impermeable cap
- Silo 3:
  - Casting of additional concrete around silo
  - Installation of protective coatings and/or membranes
  - Extension of the K-65 silos' berm to Silo 3 and utilization of the isolation techniques described for the K-65 silos.

The soil in the K-65 silos' 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 will 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 will extend to intersect a partial slurry wall and overlap the exterior grouted silo walls. It is assumed that general and granular fill, and a 1×10^{-7} cm/sec, clay borrow source with minimum horizontal permeability are regionally available.

5.2.1.1 System Requirements

This alternative will require:

- Pressure grouting and earth moving equipment
- Impermeable clay cap, slurry wall, and grout
- Relocation of Paddys Run
- Long-term maintenance and environmental monitoring program

5.2.1.2 Size and Configuration

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

5.2.1.3 Remediation Time Frame

Remediation will 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 is the only requirement.

5.2.1.5 Packaging Requirements

None.

5.2.1.6 Wastes Generated

Leachate will be generated due to Silo 1 and 2 waste subsidence following impermeable cap installation. This can be collected and processed by the FMPC wastewater treatment system.

5.2.1.7 Permits Required

The relocation of Paddys Run will 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 are no waste handling activities and, therefore, none of the associated risks.

It is possible that with dedicated long-term maintenance and monitoring, the long-term effectiveness can be maintained even though the waste has not been treated. However, the alternative remains poor in this category because it is uncertain that the containment techniques utilized will prevent contaminant migration over the long term.

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

This alternative rates average in this category because, although the containment provided does reduce the mobility of the contaminants for the short term, there is 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

Perpetual maintenance and monitoring will 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 wastes 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 total capital cost for this alternative is approximately $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 capital 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 may be 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 wastes. In situ chemical stabilization or vitrification will be utilized in addition to grouting, capping, and slurry walls. At this stage, vitrification is included as an innovative technology. The capping and external grouting required for this alternative are identical to those described for Alternative 1.

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

Following the installation of the EIE, the silo domes will be removed and the wastes stabilized. The soil underneath the silos will then be grouted to reduce the potential for migration from the contaminated zones. The cap design will be dependent on the stabilization process used: vitrified wastes require a low performance cap only to control erosion, whereas chemically stabilized wastes require a more impermeable cap to reduce leaching. A slurry wall will be installed in the berm surrounding the silos to provide an additional barrier to prevent contaminant migration.

In Situ Vitrification

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

Fume hoods will be installed over the active (melting) settings to capture any contaminated steam generated during the vitrification process. This steam will be condensed and treated by an Air Pollution Control (APC) system separate from the general building ventilation system. This system will remove radon, volatile metals, and contaminated dust.

Electrodes will be energized and blocks of wastes will be melted. The melting process will be controlled so that all of the silo wastes and much of the silo walls will be vitrified. Thermocouples will be 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 will be added to the wastes 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. Since the wastes are somewhat dry, especially those in Silo 3, the chemicals will be added as a slurry. The amount of stabilizing agent required and the subsequent volume increase will depend on the system used and will require treatability studies. If the waste volume is increased by more than 10-20 percent, the berms around the silos will have to 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.

5.3.1.1 System Requirements

This alternative will require:

- EIE
- Earth moving equipment
- Grout injection 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 stabilization will require an auger and mixers and vitrification will require melters, fume hoods, and an APC system. Either of these stabilization technologies will require 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.

5.3.1.4 Spatial Requirements

The spatial requirements are as follows:

• 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 and grout preparation facilities	30,000 sq ft

5.3.1.5 Packaging Requirements

None.

5.3.1.6 Wastes Generated

The following wastes will be generated:

- Contaminated steam, volatile metals, 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 off the FMPC property, substantive conditions of the existing NESHAP or NPDES permits will be complied with. The relocation of Paddys Run will 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 is removed and there is 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 wastes will be permanently located over the Great Miami Aquifer and near a major population center (Cincinnati, Ohio). Although the long-term stability of the immobilized wastes 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 will greatly reduce the migration of contaminants to the air or groundwater.

5.3.2.3 Reduction in Toxicity, Mobility and Volume

Although the volume of the silo wastes is not affected by this alternative (the volume of the final waste form may increase or decrease, dependent on the stabilization technology employed), the mobility and toxic characteristics of the wastes are 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 will 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

NEPA requirements may have to be met due to the environmental impacts associated with the partial relocation of Paddys Run. 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. As previously discussed, the in situ vitrification option requires substantial testing and development. This alternative rates poor in this category.

5.3.4 Cost

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

5.3.5 Additional Data Needs

Prior to the selection of the vitrification option, a substantial amount of testing and development will be required to validate the process as a viable option. Treatability studies will 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 cost. As previously stated, appreciable testing and development will be required with no guarantee of success. The use of conventional stabilization technologies is more likely to be effective in completely stabilizing the wastes; however, treatability testing will still be required prior to full endorsement of this technology.

For a nonremoval alternative, with its immobilization and isolation of the wastes, 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 wastes provides for waste removal, silo demolition, and disposal of both the wastes and silo debris in an engineered on-site disposal facility. The wastes will be mechanically, pneumatically, or hydraulically removed from the silo and packaged for on-site disposal without interim treatment or stabilization (Figure 5-1). The mechanical, hydraulic and pneumatic methods are described in Section 4.2, as are the designs for the engineered on-site disposal facility.

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

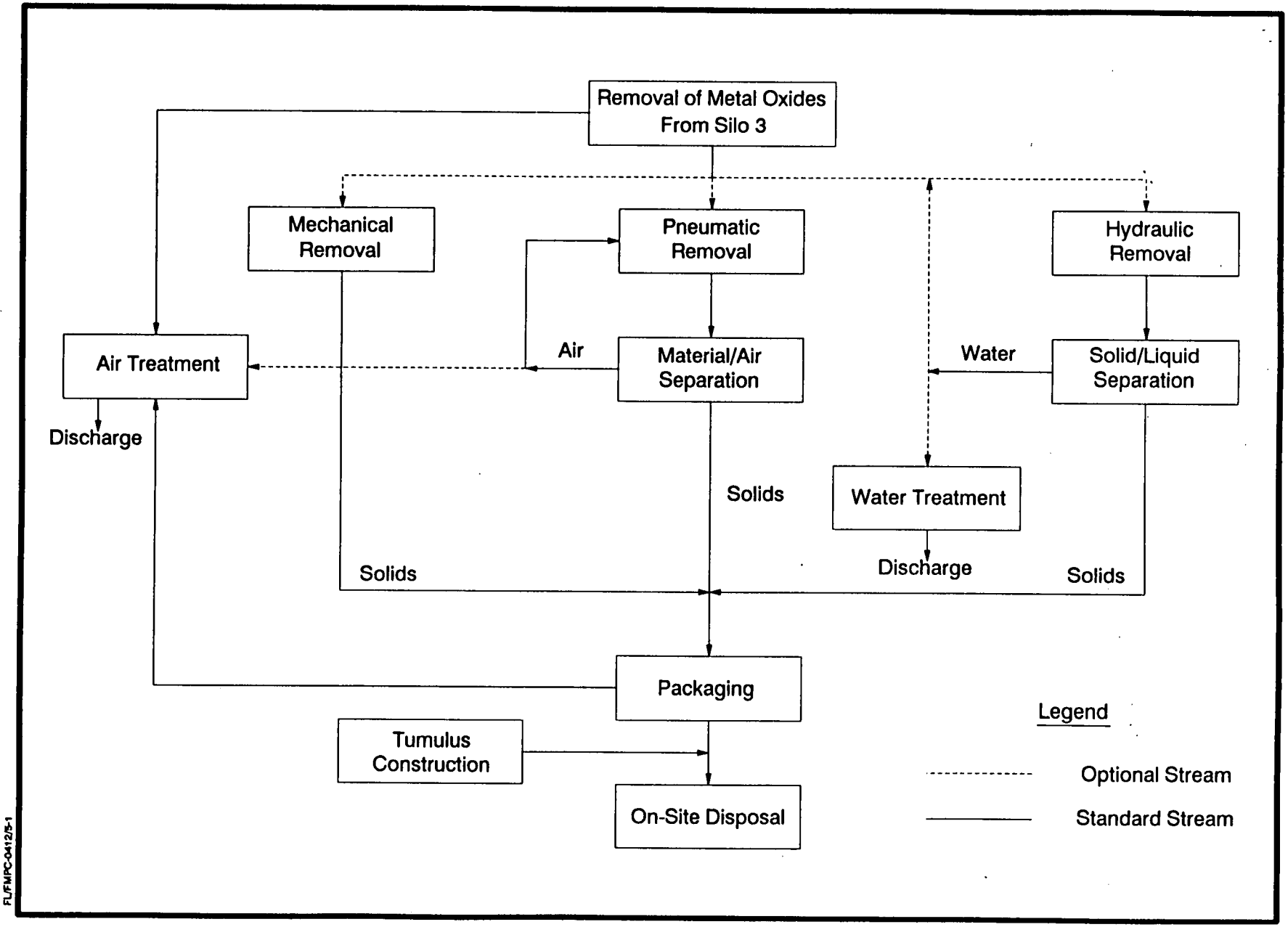

FIGURE 5-1. ALTERNATIVE 3 - REMOVAL AND ON-SITE DISPOSAL - SILO 3

5.4.1.1 System Requirements

This alternative will require:

- EIE
- Waste removal equipment
- For hydraulic removal- a water supply and a water treatment system
- For vacuum removal- an air supply and an air treatment system
- 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 4.2 will be designed to handle 1 to 5 cubic feet of material per minute.

5.4.1.3 Remediation Time Frame

Remediation will 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 as follows:

• 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 will 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, shall be followed when choosing a container.

5.4.1.6 Wastes Generated

The following wastes will be generated:

- Waste water from hydraulic removal (will be recycled where possible)
- 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 off the FMPC property, substantive conditions of the existing NESHAP or NPDES permits will 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 involves the risk of a waste handling accident during removal, packaging, or transport to the on-site disposal facility, the wastes, in their present state, are relatively stable and of low radiological activity.

The long-term effectiveness is average because the wastes have not been completely stabilized and will be located over the Great Miami Aquifer near a major population center (Cincinnati, Ohio).

5.4.2.2 Protection of 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

This alternative is average. Although the wastes are reasonably stable and immobile in the disposal facility, their toxicity and volume have not been 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 will 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 wastes will 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 capital cost for this alternative is approximately $49 million.

5.4.5 Additional Data Needs

None.

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 cost. The long-term effectiveness from

a health and environmental standpoint is average, however, as untreated wastes will 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 wastes is identical to Alternative 3 with the exception of the final disposal of the wastes. This alternative calls for the off-site disposal of the untreated wastes and silo debris, thereby precluding the need for an on-site disposal facility. The additional requirements to be met for this alternative involve packaging and transportation to an approved off-site disposal facility (Figure 5-2).

5.5.1.1 System Requirements

This alternative will require:

- EIE
- Waste removal equipment
- For hydraulic removal- a water supply and a water treatment system
- For vacuum removal- an air supply and an air treatment system
- Miscellaneous utilities
- 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 4.2 will be designed to handle 1 to 5 cubic feet of material per minute.

5.5.1.3 Remediation Time Frame

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

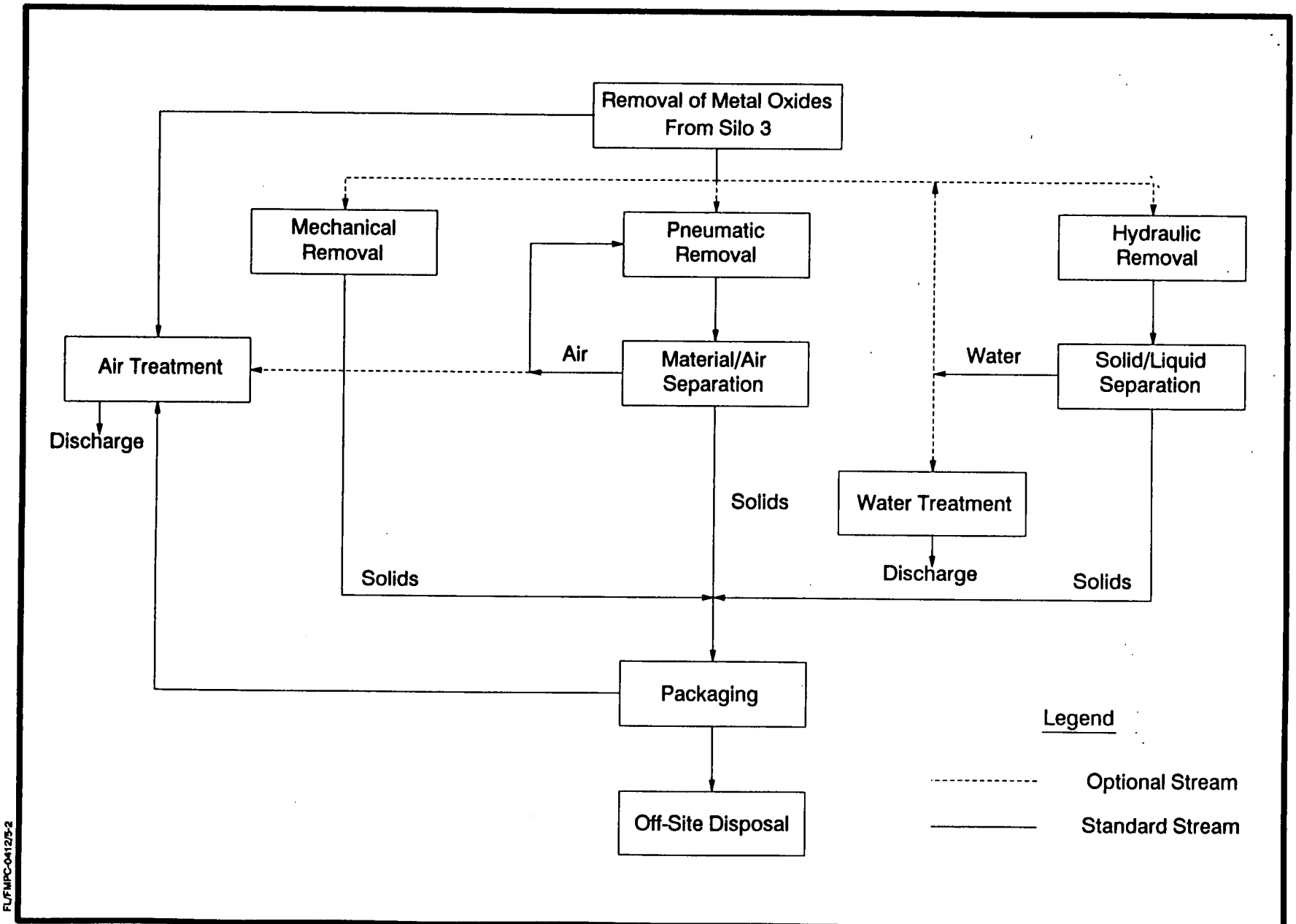

FIGURE 5-2. ALTERNATIVE 4 - REMOVAL AND OFF-SITE DISPOSAL - SILO 3

5.5.1.4 Spatial Requirements

The spatial requirements are as follows:

• 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 wastes 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 4.9.3).

LSA

Due to the specific activity requirements for shipping LSA quantities, the Silo 3 wastes will have to be blended with materials of a lesser specific activity. Operable unit boundaries could be crossed to provide this additional material (e.g., fly ash). LSA boxes measuring 96 cubic feet can be used.

Type B

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

The wastes will be placed in 55-gallon drums and placed in Type B overpacks.

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

5.5.1.6 Wastes Generated

The following wastes will be generated:

- Wastewater from hydraulic removal (will be recycled where possible)
- 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 off the FMPC property, substantive conditions of the existing NESHAP or NPDES permits will be complied with. Permits/licenses will be required to transport the wastes 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 wastes to an off-site disposal facility.

The long-term effectiveness is above average and rates higher than the previous alternative as the wastes are 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 wastes 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

This alternative is average in this category. Although the wastes are reasonably stable and immobile in the disposal facility, their toxicity and volume have not been 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 will 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 capital cost for this alternative is approximately $9 million if the wastes are shipped as LSA material and approximately $25 million if the wastes are 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 packaging and shipping 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 wastes will be permanently stored in either Silo 3 or Silo 4 following its rehabilitation. Following final disposition of the wastes, a berm and a cap will be installed.

The removal techniques and the EIE used for this alternative are similar to those described for Alternative 3. Additional containment will be required around Silo 4. The cap and berm design will be identical to those described in Alternative 1.

5.6.1.1 System Requirements

This alternative will require:

- 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 hydraulic removal - a water supply and a water treatment system
- For vacuum removal - an air supply and an air treatment system
- Miscellaneous utilities

5.6.1.2 Size and Configuration

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

5.6.1.3 Remediation Time Frame

Remediation will 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 as follows:

• 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 is involved in this option.

5.6.1.6 Wastes Generated

The following wastes 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

5.6.1.7 Permits Required

Should it be necessary to discharge to the air or water off the FMPC property, substantive conditions of the existing NESHAP or NPDES permits will be complied with. The relocation of Paddy Run will 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 wastes have not been 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

Although the wastes will remain reasonably stable in their presently dry and powdery form, their toxicity and volume will not have been 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 assured.

5.6.3.2 Reliability

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

5.6.3.3 Maintenance/Operation

The rehabilitated silo will 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 will 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.

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 silos' wastes provides for waste removal, treatment, and on-site disposal in an engineered disposal facility. The wastes will be mechanically, pneumatically, or hydraulically removed from the silo and then chemically or physically stabilized before packaging and on-site disposal (Figure 5-3). The silos and berms will 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 identical 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.

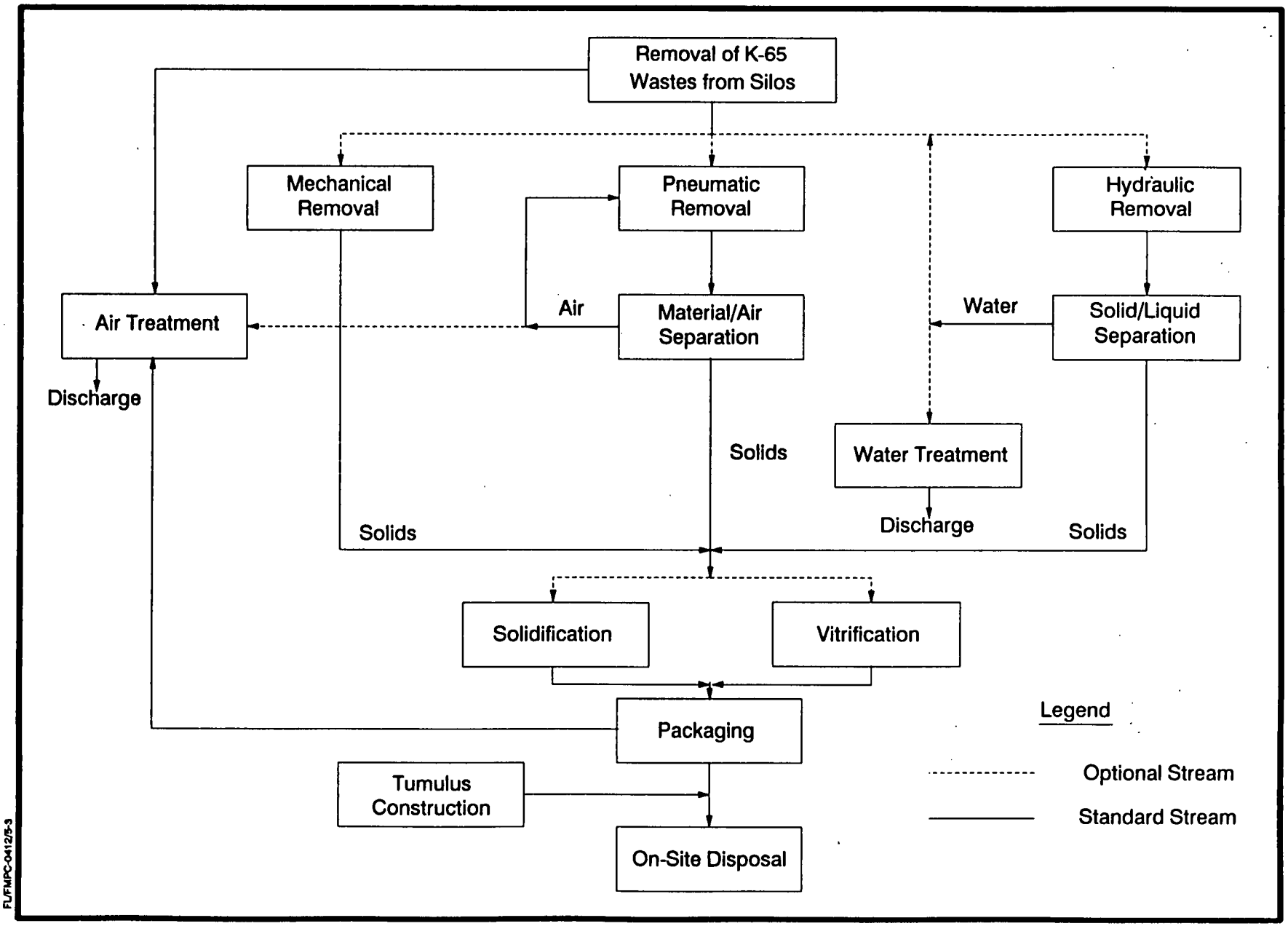

FIGURE 5-3. ALTERNATIVE 6 - REMOVAL, TREATMENT, ON-SITE DISPOSAL - SILOS 1, 2

5.7.1.1 System Requirements

This alternative will require:

- EIE
- Waste removal equipment
- Stabilization equipment (conventional or vitrification)
- For hydraulic removal- a water supply and a water treatment system
- For vacuum removal- an air supply and an air treatment system
- 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 will require process equipment that includes driers, mixers, conveyors, and some type of automated packaging equipment. Vitrification will require 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.

5.7.1.3 Remediation Time Frame

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

5.7.1.4 Spatial Requirements

The spatial requirements are as follows:

• 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 will 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, will be followed when choosing a container.

5.7.1.6 Wastes Generated

The following wastes will be generated:

- Water from hydraulic removal method (will be recycled where possible)
- 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 off the FMPC property, substantive conditions of the NESHAPS or NPDES permits will 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 wastes will 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 will greatly reduce the potential for the migration of contaminants to the air or groundwater.

5.7.2.3 Reduction in Toxicity, Mobility and Volume

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 wastes is not reduced, the toxicity characteristic is potentially greatly reduced. The volume of the disposed wastes will 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 will 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 wastes above the Great Miami Aquifer may prove to be difficult even though the wastes have been treated. This alternative is rated below average in this category.

5.7.3.5 Special Engineering and Equipment

This alternative may 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 capital cost for this alternative is approximately $65 million. Unlike Alternative 2, there is no significant difference between vitrification and stabilization because equipment costs are a small percentage of the total cost.

5.7.5 Additional Data Needs

Treatability studies are 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 wastes, they still will 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 wastes will 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.

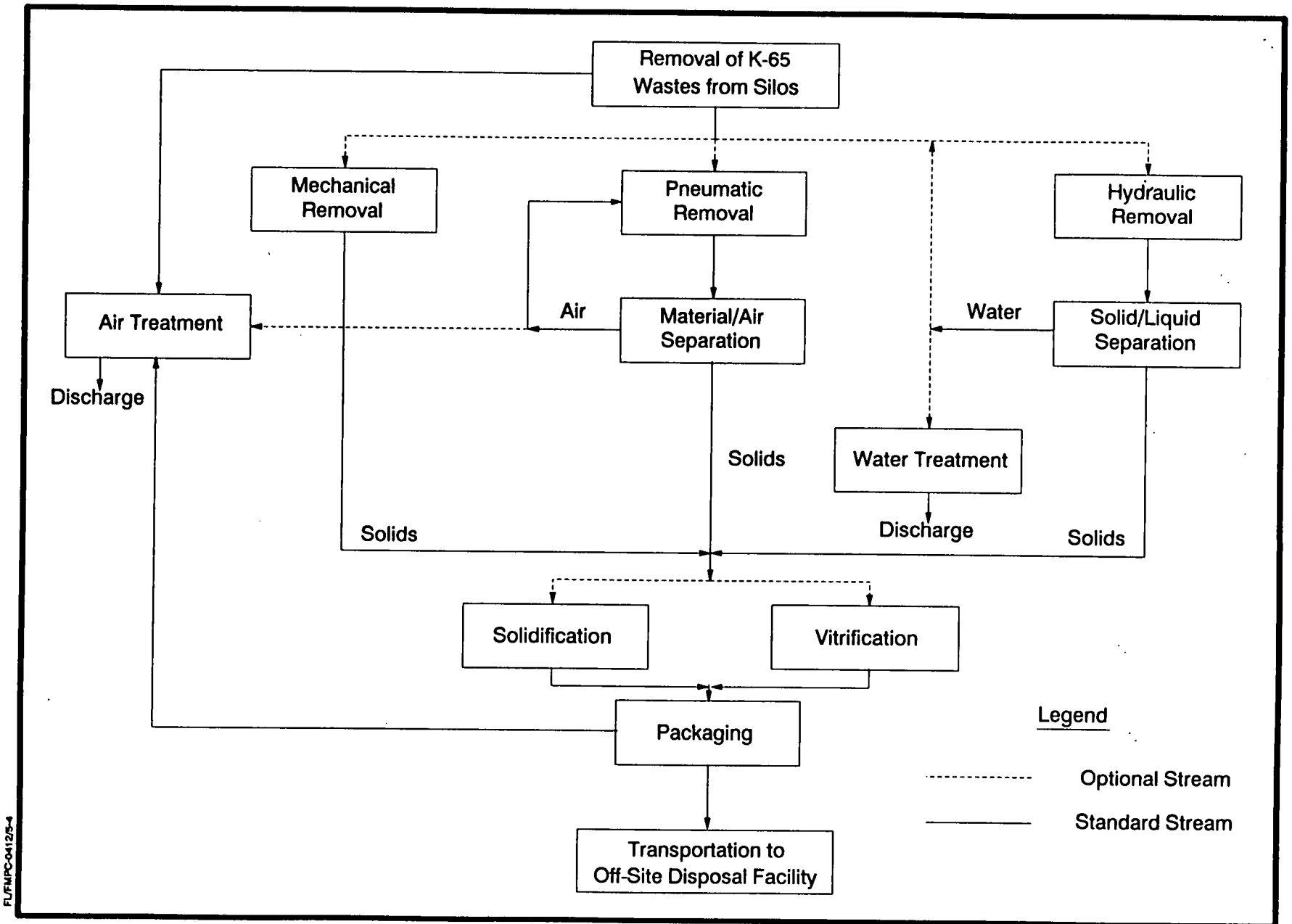

FIGURE 5-4. ALTERNATIVE 7 - REMOVAL, TREATMENT, OFF-SITE DISPOSAL - SILOS 1, 2

5.8.1.1 System Requirements

This alternative will require:

- EIE
- Waste removal equipment
- Stabilization equipment (conventional or vitrification)
- For hydraulic removal - a water supply and a water treatment system
- For vacuum removal - an air supply and an air treatment system
- Miscellaneous utilities
- 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 will require process equipment that includes driers, mixers, conveyors, and some type of automated packaging equipment. Vitrification will require 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 Remediation Time Frame

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

5.8.1.4 Spatial Requirements

The spatial requirements are as follows:

• 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 silos' wastes are LSA containers and Type B containers. Type A quantities and Limited Quantities will not be considered for the reasons previously stated.

LSA

In order to meet the LSA specific activity limits, the wastes will have to be blended with material of a lesser activity. The obvious choice for this material is the silo berm material as it is slightly contaminated and also requires disposal. LSA boxes measuring 96 cubic feet can be used for this disposal option.

Type B

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

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

5.8.1.6 Wastes Generated

The following wastes will be generated:

- Water from hydraulic removal method (will be recycled where possible)
- 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 off the FMPC property, substantive conditions of the existing NESHAP or NPDES permits will be complied with. Permits/licenses will be required to transport the wastes 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 poor 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 is incurred during waste transport to the off-site disposal facility.

Long-term effectiveness of this alternative is above average due to the off-site disposal of the treated wastes 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 poor 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 wastes in a geologically stable facility that experiences little precipitation.

5.8.2.3 Reduction in Toxicity, Mobility, and Volume

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 wastes. 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 wastes. 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 will 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 wastes, the wastes will 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 capital cost for this alternative is approximately $37 million if the wastes are shipped as LSA material and $42 million if the wastes are shipped as Type B material.

5.8.5 Additional Data Needs

Treatability studies will 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 wastes by stabilization/vitrification and this, combined with off-site disposal, provides one of the most effective long-term disposal options for the K-65 silos' wastes.

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 silos' waste removal, separation of radioactive/hazardous components and nonhazardous components through various contaminant separation schemes, and subsequent on-site disposal of resultant wastes. The wastes will be removed by hydraulic or

mechanical methods (Figure 5-5). These methods have been discussed previously and will not be covered here. This alternative will also require the use of an EIE.

Dependent on the removal method selected, the wastes will 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 will begin with a multistage, nitric acid leach which will solubilize the uranium, radium, and lead, the major radionuclides of concern. This leaching process will 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 will require laboratory bench-scale testing to determine the effectiveness of the leaching and the proper acid and sludge ratios.

After leaching, the mixture will be filtered and washed to remove the dissolved components from the remaining sludge. The filtrate, containing the hazardous and radioactive components, will 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 will also precipitate calcium and some iron. The supernatant water may be recycled or require further treatment prior to discharge. The precipitated sludge will 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 in 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

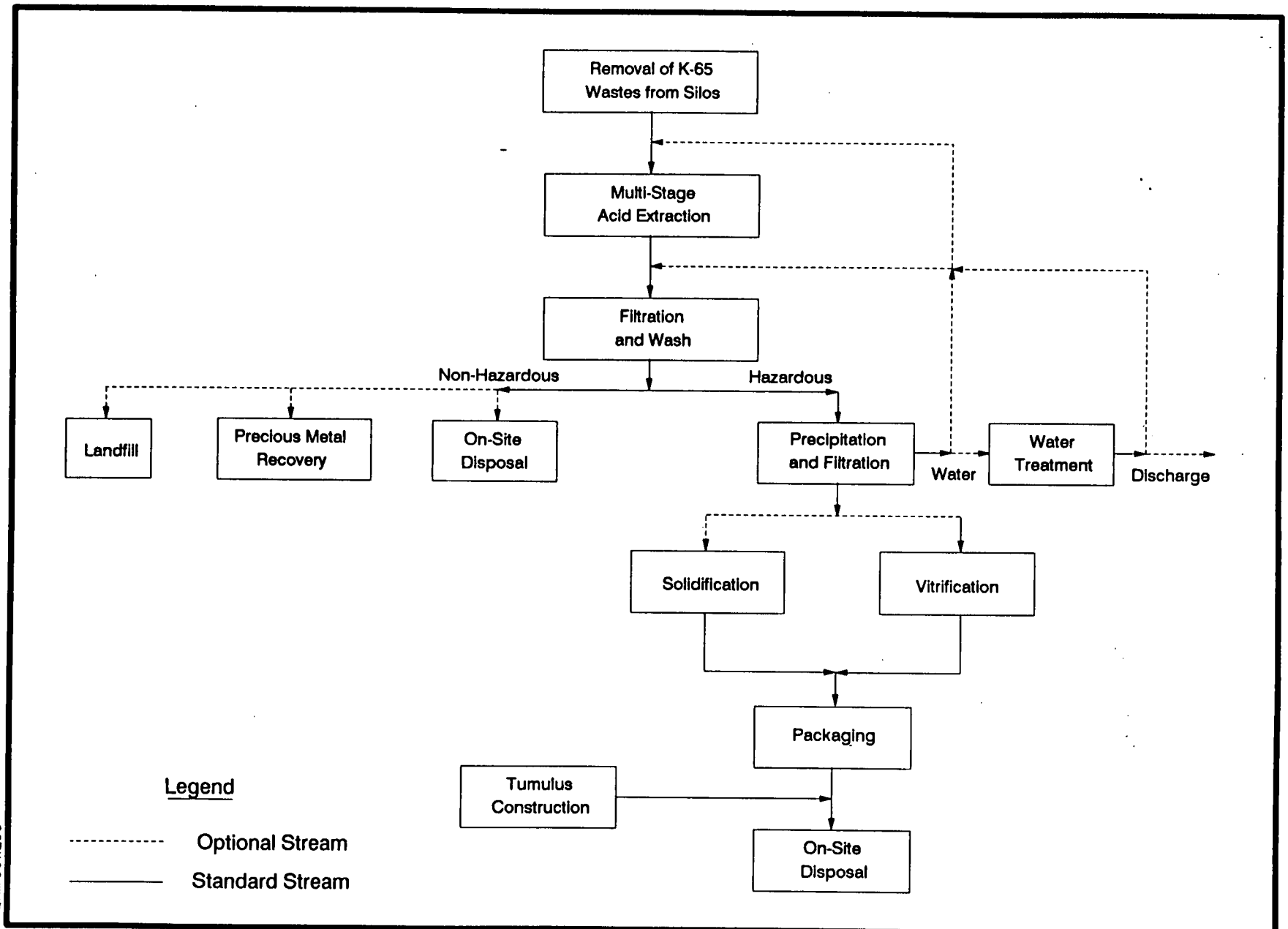

FIGURE 5-5. ALTERNATIVE 8 - CONTAMINANT SEPARATION, ON-SITE DISPOSAL- SILOS 1, 2

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105

a smelter for recovery, as an on-site smelting operation would not be cost effective due to the relatively small quantities involved.

5.9.1.1 System Requirements

This alternative requires the following:

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

5.9.1.2 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 will require process equipment that includes driers, mixers, conveyors, and some type of automated packaging equipment. Vitrification will require 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.

The contaminant separation equipment will likely 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, will take approximately 5 months. Removal of the material, treatment/separation, and packaging will take an additional 18 months. Demolition and disassembly/demobilization will 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 as follows:

• 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 will 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, shall be followed when choosing a container.

5.9.1.6 Wastes Generated

The following wastes will 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 off the FMPC property, substantive conditions of the existing NESHAP or NPDES permits will 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 wastes have been treated, immobilized, reduced in volume, and placed in secure storage, the continued presence of these concentrated wastes 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

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, will 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 will 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 wastes.

5.9.3.3 Maintenance/Operation

Perpetual maintenance and monitoring will 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 capital cost for this alternative is approximately $58 million.

5.9.5 Additional Data Needs

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

5.9.6 Screening Summary

Although the wastes are 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 wastes will 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 the following:

- EIE
- Miscellaneous utilities
- Waste removal and handling equipment
- Waste treatment and contaminant separation equipment
- Treatability testing for leaching and separation
- 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

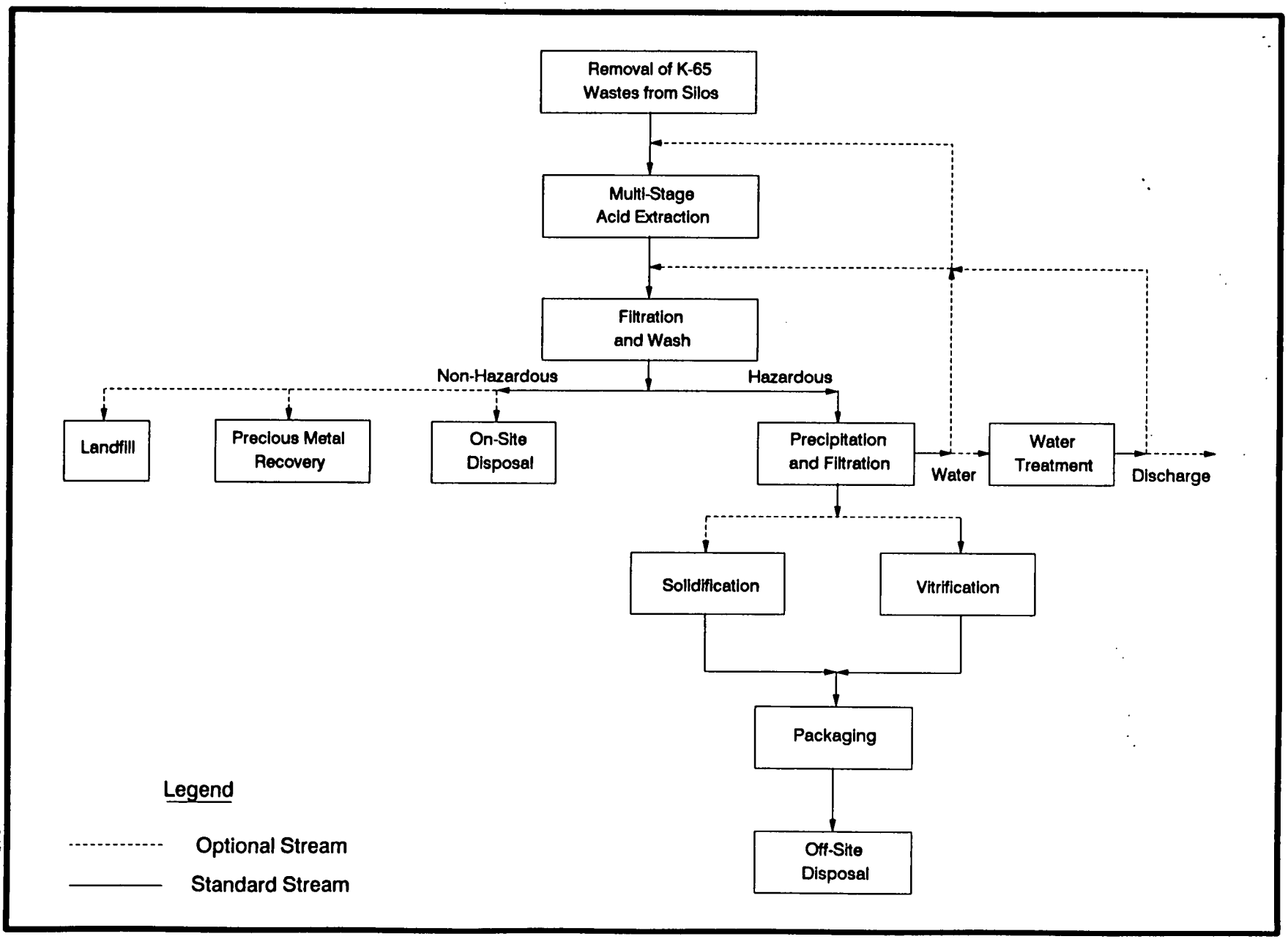

FIGURE 5-6. ALTERNATIVE 9 - CONTAMINANT SEPARATION, OFF-SITE DISPOSAL- SILOS 1, 2

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 will require process equipment that includes driers, mixers, conveyors, and some type of automated packaging equipment. Vitrification will require 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.

The contaminant separation equipment will likely 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, will take approximately five months. Removal of the material, treatment/separation, and packaging will take an additional 18 months. Demolition and disassembly/de-mobilization will require approximately six months. The total remediation time for this alternative is approximately three years.

5.10.1.4 Spatial Requirements

The spatial requirements are as follows:

• 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 wastes is Type B containers. Type A quantities, Limited Quantities, and LSA containers will not be considered for the reasons stated in Section 4.9, 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 wastes as Type B quantities, as there are no activity limits for Type B packaging. The residual wastes will be placed in 55-gallon drums and packed into Type B overpacks. The less contaminated berm material can be shipped as LSA quantities in 96-cubic-foot LSA boxes. Both the LSA boxes and Type B overpacks will be transported by truck or rail to an approved off-site disposal facility.

5.10.1.6 Wastes Generated

The following wastes will 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.)

5.10.1.7 Permits Required

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

The long-term effectiveness is good due to the off-site storage of the wastes 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 wastes in a geologically stable facility that experiences little precipitation.

5.10.2.3 Reduction in Toxicity, Mobility, and Volume

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, will 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 will 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 wastes. 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 wastes. 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 provides better long-term human health and environmental protection. There will be numerous regulatory requirements to satisfy before shipping the radioactive wastes. 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 will require treatability studies and detailed design and engineering.

5.10.4 Cost

The capital cost for this alternative is approximately $27 million.

5.10.5 Additional Data Needs

The stabilization and contaminant separation process will 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.

6.0 GENERAL SUMMARY

6.1 ALTERNATIVES RECOMMENDED FOR DETAILED ANALYSIS

Following the evaluation performed in Chapter 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 this evaluation, Alternative 5 is not recommended for further development and consideration. It requires 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 capital costs 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	1	3	2
Short-Term Environmental Protection	0	5	3	4	3	3	2	1	3	2
Long-Term Public Health	0	1	3	3	4	2	2	4	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	33	30	36

TABLE 6-2

COST ESTIMATE 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	-
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

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. At the time of this report, a silo sampling plan is being prepared and evaluated so that the radiological, chemical, and geotechnical properties of the silo wastes can be determined.

The lack of radiological data on the silo wastes directly affects 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. Geotechnical data for the silo wastes and subsoils is required to refine and evaluate the technologies employed for waste removal and capping. In addition, treatability studies are required to determine process parameters and the effectiveness of waste treatment options. All of these sampling activities and studies are scheduled in the FS for Operable Unit 4.

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
- 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).

REFERENCES

Camargo Associates, 1986, "K-65 Silos Study and Evaluation for the Feed Materials Production Center," prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

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.

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.

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

APPENDIX A

ARARs

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

A.1 INTRODUCTION

The U.S. Department of Energy (DOE) must generally comply with all provisions of federal environmental statutes and regulations, as well as all applicable state and local requirements. 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 regulatory requirements that directly and fully address or regulate the hazardous substance, pollutant, contaminant, action being taken, or other circumstance at a CERCLA site. Examples of federal statutes specifically cited in CERCLA from which requirements may apply include the Toxic Substances Control Act (TSCA), the Safe Drinking Water Act (SDWA), the Clean Air Act (CAA), the Clean Water Act (CWA), 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 address problems or situations sufficiently similar to those encountered at CERCLA sites and are appropriate to the circumstances of release or threatened release, so that their uses are well suited to the particular site. In such cases, application of these requirements would be relevant and appropriate although not mandated by law. Relevant and appropriate requirements are intended to carry the same weight as applicable requirements.

A.2 POTENTIAL 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 (OAC 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). Specific criteria for chemical concentrations have so far only been established for Lake Erie and the Ohio River.

- 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.

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 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 Cancer Potency Factors (CPFs) 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.

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
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 (OAC3745-45018)	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

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