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CONCEPTUAL DESIGN REPORT FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE, VOLUME II TECHNICAL INFORMATION DOCUMENT BOOK 1 OF 5

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

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U.S. Department of Energy
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Book 1 of 5 contains Sections 1-5

Book 2 of 5 contains Sections 6-12

Book 3 of 5 contains the figures for all sections

Book 4 of 5 contains the tables for all sections

Book 5 of 5 contains Appendix A, Unpublished Documents, and Appendix B, Acronyms

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Weldon Spring Site Remedial Action Project

Conceptual Design Report for Remedial Action at the Chemical Plant Area of the Weldon Spring Site, Volume II Technical Information Document

Book 1 of 5

Revision 0

January 1994

Prepared by

MK-FERGUSON COMPANY
and
JACOBS ENGINEERING GROUP
7295 Highway 94 South
St. Charles, Missouri 63304

for the

U.S. DEPARTMENT OF ENERGY
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Under Contract DE-AC05-86OR21548

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TABLE OF CONTENTS

NUMBER PAGE

1 INTRODUCTION 1-1

1.1 Purpose 1-1
1.2 Scope 1-2
1.3 Site Description and Location 1-5
1.4 Previous Studies 1-6
1.5 Conceptual Design Approach 1-6
1.6 Technical and Regulatory Concerns 1-7
1.7 Remediation Methodology 1-7

1.7.1 Chemical Plant Site and Raffinate Pits 1-8
1.7.2 Quarry Bulk Waste 1-8
1.7.3 Quarry Residuals 1-8
1.7.4 Vicinity Properties 1-9

1 INTRODUCTION

1.1 Purpose

The *Technical Information Document* (TID) is the second volume of a three volume set that outlines the conceptual design for the Chemical Plant Operable Unit of the Weldon Spring Site Remedial Action Project (WSSRAP). Volume I, the *Conceptual Design Report* (CDR), provides an overview and summary of the other two volumes. Volume III, the *Cost and Scheduling Document* (CSD), contains detailed cost estimates and schedules associated with construction of the designs presented in the TID. Together the three volumes form the Conceptual Design (CD) for the Chemical Plant Operable Unit at the Weldon Spring site. The CD was prepared in accordance with DOE Order 4700.1, dated March 1987; Project Management Procedures, PMP-05-1, dated January 1990; and preliminary design issues (Title I design) as described in PMP-06, dated May 1985.

The WSSRAP includes the following site operable units (SOUs): Chemical Plant, Quarry Bulk Waste Removal, Quarry Residuals/Groundwater, and Site Groundwater. Remediation of the SOUs will address all aspects related to the contamination of soils and groundwater at the site and vicinity properties. Wastes from the vicinity properties and quarry bulk wastes will be stored at the site and are therefore included in the Chemical Plant SOU and the CDR.

The TID transitions the concepts presented in the environmental documentation (the *Feasibility Study* (FS) (Ref. 1), the *Proposed Plan* (Ref. 2), and the site *Record of Decision* [ROD] [Ref.3]) into detailed design (Title II). Title II design will use the conceptual design and the criteria established in the TID as the basis for the remedial design; any changes that occur will be developed as engineering designs evolve.

Previous interim response actions at the site and construction activities already performed under the Quarry Site Operable Unit ROD are the starting point for developing of the chemical plant site conceptual designs. These activities included the construction of the material staging area (MSA), dismantlement of the chemical plant buildings and placement of the rubble in the MSA, construction of the site water treatment plant (SWTP), construction of the temporary storage area (TSA) for storage of bulk wastes transported from the quarry, and other such interim activities.

Cleanup activities at the Weldon Spring site are conducted in compliance with requirements of both the *National Environmental Policy Act* (NEPA) and the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), as amended.

1.2 Scope

The scope of the TID includes an evaluation of the two treatment methods outlined in the FS, chemical stabilization/solidification (CSS) and vitrification (VIT). However, the base case is the CSS treatment alternative, with deviations noted for VIT designs in the event that this backup technology is employed. The TID includes designs, preliminary engineering, and preparation of conceptual drawings for treatment of the site raffinate pit sludges and quarry nitroaromatic-contaminated soils, and addresses the impacts of both CSS and VIT methods in the conceptual remediation.

The TID includes the following elements:

- Introduction, background information, the conceptual design approach, and a review of previous studies.
- Interrelationship of the four WSSRAP site operable units (SOUs).
- Sampling background data and data validation procedures.
- Methodology for addressing the various conceptual design elements.
- The basis for conceptual design, including regulatory requirements, environmental safety and health issues, and quality assurance compliance.
- Conceptual designs associated with waste treatment processes, excavation and removal of wastes and building foundations, other surface facilities, disposal cell construction, site closure plan, and guidance for the preparation of a long-term surveillance and maintenance plan.

- Site operations and functions for waste treatment and processing, site closure, contracting requirements, management of quarry and building demolition wastes, vicinity properties, and waste from other site operable units.

- Preliminary assessments dealing with safety and health, quality assurance, environmental issues, and energy and resource conservation.

- Disposal cell performance assessment.

- Contingency requirements; identification and elimination of uncertainties; acquisition strategy; and any other statutory or special requirements.

- Systems analyses for site operations and designs.

- Outline of specifications and vendor information.

- Remedial design work plan.

The TID discusses elements of the conceptual designs within an integrated systems framework; the interdependence among the operations is integral to the systems analyses. The designs of all the elements are presented in Section 5; Section 6 presents operations or functions related to construction of these designs.

Sections 5 and 6 present the designs of the remediation program in three major categories: general site designs, disposal cell designs, and treatment and processing designs.

General site designs developed in the TID include:

- Waste removal
- Waste handling and transportation
- Construction materials staging area
- Site roads
- Site drainage
- Borrow materials
- Other facilities

Disposal cell designs developed in the TID include:

- Cell siting
- Cell configuration/optimization
- Cell foundation
- Liner and leachate collection and removal system
- Waste placement
- Waste containment system
- Cell drainage/water management
- Operation and maintenance

Treatment and processing designs developed in the TID include:

- Chemical stabilization/solidification
- Vitrification
- Volume reduction
- Dewatering
- Decontamination
- Additional treatments

Two other segments, site closure and long term monitoring, are major components of Sections 5 and 6. Section 8, Cell Performance, is also included to assess the proposed cell design.

Preferred clean up options for the Chemical Plant Operable Unit were conceptually designed and evaluated by developing a workable design approach, developing design criteria, and identifying design issues to be resolved during Title II design. Plans for collecting any additional site characterization data will be based on the needs for design information.

Many of the designs and operations described in the TID will be performed concurrently; for example, waste placement will be performed with other activities throughout the construction of the disposal cell. Some facilities must be completed before other activities begin. For example, the construction materials staging area (CMSA), must be completed before borrow materials are transported from off-site sources. Other activities, such as site roads, site drainage, or clearing of the cell footprint, can proceed during construction of the CMSA. The

tentative sequence presented in Table 1-1 shows the general progression of activities from initiation of construction through site closure. A detailed schedule will be developed during Title II design.

1.3 Site Description and Location

The Weldon Spring site is located in St. Charles County, Missouri, approximately 30 mi west of St. Louis, near the town of Weldon Spring (Figure 1-1). The site is comprised of two noncontiguous areas: the Weldon Spring Chemical Plant (WSCP) and a quarry that is located approximately 4 mi southwest of the chemical plant site. The chemical plant site and the quarry are being remediated as separate operable units; however, wastes removed from the quarry will be transported to the TSA located at the chemical plant site. Treatment and/or disposal of the quarry wastes will therefore form part of the chemical plant site remediation program, which is the subject of this *Conceptual Design Report*.

Properties adjacent to the WSCP include: the August A. Busch Memorial Conservation Area, to the north; the U.S. Army Reserve Training Area, to the west; and the Weldon Spring Conservation Area, to the east and south (Figure 1-2). Several small areas on the adjacent properties, referred to as the vicinity properties, are chemically and/or radioactively contaminated as a result of previous oprations at the site. Contaminated wastes on the vicinity properties will be excavated and transported to the chemical plant site for subsequent disposal.

The general site layout of the chemical plant area, herein referred to as the site, is presented in Figure 1-3. The site includes 217 acres containing approximately 40 buildings and structures, four raffinate pits, two ponds, and two former dump areas. It is chemically and radioactively contaminated as a result of previous activities related to the processing of explosives and uranium ore. During the 1940s, nitroaromatic explosives were processed by the Army at the Weldon Spring Ordnance Works; during the 1950's and 1960's, radioactive materials were processed at the site by the U.S. Department of Energy's (DOE) predecessor agency. The chemical contaminants present include nitroaromatic compounds, metals, and a few organic and inorganic compounds; radioactive contaminants present are uranium and thorium decay series. A more detailed history of the site and the contamination is available in various documents including the *Remedial Investigation* (RI) (Ref. 4) and the *Feasibility Study* (Ref.1).

The layout of the site prior to construction of the disposal cell, with the TSA, MSA and the SWTP in place, is shown in Figure 1-3. The TSA will store wastes from the quarry; the MSA will store wastes and rubble from the buildings and other structures that were demolished at the site; and the site water treatment plant will treat contaminated wastewater originating at the site.

1.4 Previous Studies

Other studies performed at the site have produced documents pertinent to the designs presented in the TID. These studies were planned specifically to fill data gaps and address issues relevant to development of WSSRAP designs and are referred to throughout the report as supporting studies. Supporting studies that are incomplete at this time are referred to throughout the text as on-going or in-progress. Data that were available, though not in final form, are referred to as preliminary data. Other studies that provide data or other necessary information to the TID are discussed in Section 2.

1.5 Conceptual Design Approach

The TID was prepared in accordance with the outline and procedures detailed in the CDR *Scoping Document* (Ref. 5). The various designs presented in TID Sections 5 and 6 follow the design methodology discussed in Section 3. The design methodology includes the following steps:

- Review the base of information.
- List functional and performance requirements.
- Identify design alternatives.
- Evaluate design alternatives.
- Select and detail the preferred alternative.
- Discuss technical uncertainties and operational requirements.

Information from supporting studies was incorporated into the conceptual design effort, when appropriate, and used to evaluate the various design alternatives. In most instances, the preferred alternative design was selected by applying a modified value engineering (MVE) approach. The MVE method relied on the establishment of criteria by which to evaluate alternatives, and a point value system to identify the best alternative. Feasible options, such

as design modifications that could be implemented, are presented in observational approach tables; additional data needs for the preferred alternatives are identified and listed in data needs tables.

Because most of the designs are operationally interdependent, it was necessary to maintain a systems-wide perspective. This systems analysis approach ensured that each design engineer was focusing not only on the particular design, but also on the impacts and relationship with all related designs and operations.

1.6 Technical and Regulatory Concerns

The designs and operations presented and discussed in the TID conform with all applicable Federal, State, and local regulations. The general regulatory requirements and the corresponding regulatory agencies are listed in Section 4. These include the following:

- U.S. Environmental Protection Agency (EPA).
- U.S. Department of Energy Orders.
- *National Environmental Policy Act* regulations.
- Occupational Safety and Health Administration (OSHA).
- Other Federal regulations.
- State of Missouri regulations.
- St. Charles County ordinances, codes, and regulations.

In compliance with the CERCLA and the NEPA, the DOE conducts periodic public meetings and hearings on issues that relate to the WSSRAP. The WSSRAP FS was issued for formal public comment on November 20, 1992; the design for construction of the disposal cell was introduced to the public and agencies at a public meeting held in St. Charles, Missouri on December 16, 1992. Designs developed in this TID will be presented to Federal agencies, the State, and the public in various public forums.

1.7 Remediation Methodology

Remediation at the site will consist of treatment of contaminated wastes and storage of both treated and untreated wastes in an engineered disposal cell. The major sources of wastes are the chemical plant site and raffinate pits, quarry bulk wastes, quarry residuals, and the

vicinity properties. The proposed remediation for the waste derived from each of these sources is discussed in the following subsections. Treatment of the raffinate sludges, quarry sludges, and quarry nitroaromatic-contaminated soils will consist of chemical solidification/stabilization or, as an alternative, vitrification.

1.7.1 Chemical Plant Site and Raffinate Pits

The contaminated soil and rubble from the chemical plant site will be transported to and stored in an engineered disposal cell at the site. Refer to Sections 5.1.2 and 6.1.2 for an explanation of the waste removal plan, and Sections 5.1.3 and 6.1.3 for a discussion of the waste handling and transportation scenario. Most liquid wastes will be treated in the SWTP and once release criteria are met, subsequently discharged. The sludges from the raffinate pits will be dewatered, transported to the CSS or VIT plant for treatment, and the treated product transported to the disposal cell. Refer to Sections 5.3 and 6.3 for details of treatment and processing methods. The disposal cell will contain all the contaminated wastes from the Weldon Spring site (except for RCRA listed waste stored in Building 434), the quarry, and the vicinity properties.

1.7.2 Quarry Bulk Waste

Contaminated soils, rubble, and sludges from the quarry are referred to as quarry bulk wastes. The quarry bulk wastes will be excavated and transported to the chemical plant site for temporary storage in the TSA and subsequent final disposal in the engineered cell. The nitroaromatic-contaminated soils and sludges from the quarry will be treated in the CSS or VIT plant prior to disposal in the cell. The quarry water will be treated in the quarry water treatment plant and released to the Missouri River.

1.7.3 Quarry Residuals

Soils and rock that have been contaminated by contact with contaminated materials are referred to as quarry residuals. Once the bulk of the contamination in the quarry is removed, the residual soils and rock will be evaluated. The extent of contamination and the quantity of the quarry residuals will not be known until after the quarry bulk waste is excavated; therefore, the current conceptual design for the chemical plant SOU does not consider the fate of the quarry residuals as part of the CDR.

1.7.4 Vicinity Properties

The vicinity properties are contaminated areas outside the chemical plant and quarry. These contaminated areas will be excavated and the waste will be transported to the chemical plant for storage and disposal in the disposal cell.

TABLE OF CONTENTS

NUMBER PAGE

2 BACKGROUND DATA FOR CONCEPTUAL DESIGN 2-1

2.1 General 2-1
2.2 Data Quality 2-1

2.2.1 Remedial Investigation/Feasibility Study and Environmental Monitoring 2-2
2.2.2 Historial Site Data 2-2
2.2.3 Remedial Action Engineering Data 2-2
2.2.4 Conceptual Design Supporting Studies 2-2

2.3 Site Data Base 2-3

2.3.1 Surface Data 2-4
2.3.2 Subsurface Data 2-5
2.3.3 Waste Characterization Data 2-6

2.3.3.1 Physical Characterization Data 2-7
2.3.3.2 Chemical Characterization Data 2-8
2.3.3.3 Radiological Characterization Data 2-9

2.3.4 Waste Treatment Data 2-9

2.3.4.1 Chemical Stabilization/Solidification 2-10
2.3.4.2 Vitrification 2-10

2 BACKGROUND DATA FOR CONCEPTUAL DESIGN

2.1 General

Background data constitute relevant information that was generated to support site characterization and conceptual design. Although a substantial amount of background data are presently available, the conceptual design may identify the need to obtain additional data. The following four general categories of background information are available to support conceptual design of the disposal cell:

- Remedial Investigation/Feasibility Study (RI/FS) and environmental monitoring data - these data are the result of characterization studies undertaken in support of the site operable unit and annual environmental monitoring conducted in accordance with DOE Order 5400.1.

- Pre-remedial engineering data - site engineering data pertaining to construction and development of the Weldon Spring Ordnance Works and Weldon Spring Chemical Plant.

- Remedial action engineering data - site engineering data generated to support remedial action construction for the site operable unit.

- Conceptual design supporting studies - a suite of studies specifically undertaken to provide guidance and direction for major design components of the disposal cell.

2.2 Data Quality

The *Project Management Contractor Quality Assurance Program* (QAP) (Ref. 6) establishes quality assurance requirements for all activities performed at the Weldon Spring Site Remedial Action Project (WSSRAP) by the Project Management Contractor (PMC). The QAP is designed to comply with the quality assurance program requirements for nuclear facilities; ANSI NQA-1-1989, established by the American National Standards Institute (Ref. 7), and the quality assurance criteria contained in U.S. Department of Energy (DOE) Order 5700.6c.

2.2.1 Remedial Investigation/Feasibility Study and Environmental Monitoring

The database compiled from RI/FS characterization studies has been validated in accordance with the *Environmental Data Administration Plan* (EDAP) (Ref. 8). Additional procedural requirements for collection and analysis of environmental data and for database management are contained in the *WSSRAP Environmental Quality Assurance Project Plan* (EQAPjP) (Ref. 9).

2.2.2 Historial Site Data

Because operations at the chemical plant occurred 25 to 50 years ago, the specific controls on the quality of the data generated to support construction of the ordnance works, chemical plant buildings and utilities, and to support waste management, are essentially unavailable. Standard engineering procedures for the different phases of site development varied. The most suspect information is probably that pertaining to the ordnance works phase of site development, while the most reliable information is drawings made for construction of the chemical plant buildings, which show foundation details and utilities. However, as a general rule the information from these sources should be regarded with some skepticism. In cases where these data may have a significant impact on design, contingency measures and or field verification activities should be developed, as appropriate, to ensure that designs are optimized.

2.2.3 Remedial Action Engineering Data

Data quality controls for geotechnical drilling and sampling, geotechnical laboratory analysis, and geophysical surveys performed to initially evaluate geotechnical design parameters and evaluate site suitability for construction of a long-term waste disposal facility are contained in the *Geophysical/Geotechnical Investigations Sampling Plan* (Ref. 10), the *Hydrogeological Investigations Sampling Plan* (Ref. 11) and other geotechnical sampling plans (Ref. 12 and 13).

2.2.4 Conceptual Design Supporting Studies

The *Conceptual Design Supporting Studies Work Plan* (Ref. 14) presents an overall organizational structure, logic sequence, and procedural guidelines for administration and accomplishment of the supporting studies. It provides details regarding procedures and quality assurance/quality control requirements to be used to perform conceptual design supporting

studies (CDSS). Specific guidance is developed in this plan to illustrate integration and application of the *Nuclear Quality Assurance Program* (NQA-1) (Ref. 7) criteria regarding the CDSS program.

2.3 Site Data Base

The site database includes all information maintained or generated by the site that would be useful for performing conceptual design. The site database consists of electronic files, hard files of data and supporting documentation, printed reports and datasets containing information such as results of chemical analyses, waste volume estimates, waste type inventories, survey elevations and coordinates, geological logs, treatability studies, and results of geotechnical analyses of site soils.

Chemical data and some radiological data are obtained from analyses performed by subcontract laboratories that provide analytical support services. Additional radiological analytical capabilities are provided by the on-site radiological laboratory. The radiological laboratory is operated by the Environmental Safety and Health (ES&H) Department, and provides rapid turnaround for isotopic analyses of soil and air samples and total uranium analyses of water. These data are maintained in hard copy files and analytical runs are logged chronologically.

Chemical data are maintained as electronic records in a computerized database that is managed by Generic Universal Report Utility (GURU), a customized software program (Ref. 15). The WSSRAP database is a microcomputer-based system utilizing dBASE III Plus software. The GURU program was developed by the PMC for use in assessing analytical data. The GURU program provides a computerized format for utilizing a wide range of analytical data collected at the site from characterization and monitoring data. GURU functions include data searches, data extraction and filtering, simple statistical operations, and report generation. GURU also protects the integrity of the analytical database by allowing users access to data, but restricting modifications or deletions to the system. Information regarding the activities related to planning, collection, analysis, and administration of data and documentation contained in the WSSRAP database are provided in the *Environmental Data Administration Plan* (Ref. 8).

Chemical and physical data are manipulated and displayed for different applications using the WSSRAP Geographic Information System (GIS) which is maintained on a VAX 4000 and

utilizes ArcInfo software. A database is maintained for the GIS includes information sets (coverages) on chemical and radiological analyte concentrations in soil, surface water and groundwater; soil engineering and geotechnical properties; surface topography; geology; surface hydrology; vegetation; and cultural features such as roads, piping, utilities and buildings. The precise plotting capabilities of the WSSRAP GIS system are routinely used to generate specialized location maps; assess site conditions with respect to particular data vectors such as soil type; perform trend-surface analysis; and to depict the results of mathematical modeling.

Computer aided design (CAD) has been utilized at WSSRAP to increase versatility for site planning. CAD efforts have employed MICROSTATION and INROADS software running on INTERGRAPH machines to digitize as-built drawings for the chemical plant structures and utilities.

2.3.1 Surface Data

Figure 2-1 summarizes the main surface data components for the site. Surface data are basically made up of three types of data:

Surficial chemical and radiological data from the remedial investigation and subsequent characterization efforts.

Topographic survey elevations and coordinates.

As-built drawings for the chemical plant buildings and utilities.

Surficial chemical and radiological data consist of analytical results that have been used to define the magnitude and extent of surface soil contamination for the chemical plant site, including the disposal cell footprint. These data were primarily collected to support the remedial investigation for the chemical plant site and the results are summarized in the *Remedial Investigation for the Chemical Plant Area of the Weldon Spring Site* (Ref. 4).

The PMC Engineering Department currently maintains a topographic database that is updated as new information becomes available. In late 1989, prior to any significant construction of support facilities or dismantlement or remediation of existing structures or properties, a topographic map was produced by aerial photogrammetry. This map has been

periodically updated with information gathered from available site drawings and new data derived from record drawings. A new aerial topographic map is currently in preparation. This topographic information will be based on a coverage of over 10,000 acres and more than 50 control points (targets) set by global positioning system (GPS) to American Society for Photogrammetry and Remote Sensing (ASPRS) standards for a scale of 1:1200 and a 2-ft contour interval. This new topographic coverage will update or replace all existing information.

As-built drawings for the chemical plant structures and utilities have been digitized and are maintained in CAD files for use in site development engineering. These files contain all major structures and utilities for the site and were generated from drawings contained in site files. The CAD files utilize INROADS software to perform volume calculations and generate cross sections. Currently, the CAD database is providing reference drawings to assist in building demolition and to formulate the excavation plan for contaminated soils and building foundations.

2.3.2 Subsurface Data

Figure 2-2 illustrates the principal types of subsurface data available for the site, the major formats for which the data are available, access to data utilities such as GURU or GIS, and typical applications for the data.

Geotechnical data obtained to determine site suitability (Ref. 16) and soil data obtained for Title II design are contained in the *WSSRAP Chemical Plant Geotechnical Investigations Sampling Plan* (Ref. 17) and Supporting Study 2A *WSSRAP Disposal Facility Geotechnical Characterization Report* (Ref. 18). Test results and lithologic descriptions have been used to develop electronic tables and isopach maps using the surface trend analysis options offered by the GIS. Additional information is contained in *Supporting Study 11, WSSRAP Disposal Facility Seismic Criteria and Assessment* (Ref. 19) and *Supporting Study 6A, WSSRAP Disposal Facility Borrow Material and Borrow Area Selection Criteria* (Ref. 20).

Geological and hydrological data for the site have been collected primarily to support site characterization and environmental monitoring efforts required by the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) and DOE Order 5400.1. The *Remedial Investigation Report for the Chemical Plant Area of the Weldon Spring Site*

(Ref. 4), the *Proceedings of the Geosciences Workshop* (Ref. 21), and the annual site environmental reports (Ref. 22, 23, 24, and 25) are the principal references for this information. Copies of geological logs, well construction diagrams, well test results, and monitoring well hydrographs are contained in ES&H departmental files. Water level elevations are collected on a monthly basis for all monitoring wells. These data are maintained in electronic tables using Quattro Pro and are updated quarterly. The data are plotted as hydrographs, or as potentiometric surfaces using the GIS. Results of aquifer tests performed in the shallow bedrock aquifer are reported in the *Aquifer Characteristics Data Report* (Ref. 26).

Chemical data for subsurface conditions consist for the most part of groundwater quality data. This information is contained in the GURU database and reported in the annual site environmental reports (Ref. 22, 23, 24, and 25).

Geophysical surveys conducted on site prior to 1988 are summarized in the *Geophysical/Geotechnical Investigation Sampling Plan* (Ref. 10). In 1988, Geotechnology Services performed an extensive geophysical survey of the chemical plant site (Ref. 35) using shallow electromagnetic (EM) induction, magnetometry, very low frequency electromagnetics (VLF EM), seismic refraction and reflection, spontaneous potential, and vertical electrical resistivity soundings. Borehole geophysics were performed on two angled borings in 1989 utilizing resistivity, spontaneous potential, natural gamma, neutron, density, sonic, caliper, temperature, and directional survey techniques. These data are reported in the *WSSRAP Chemical Plant Geotechnical Investigation* (Ref. 17). Additional EM and magnetometer surveys have been performed by Quantum Geophysics, Inc. to provide subsurface information for site development.

2.3.3 Waste Characterization Data

Waste characterization data for the various contaminated areas and materials range from very little to extensive. WSSRAP wastes that are relatively well characterized include the raffinate sludge, contaminated soil, tributyl phosphate (TBP), and liquid and solid wastes stored in the on-site *Resource Conservation Recovery Act* (RCRA) storage facility (Building 434) and contained in the process buildings. Poorly characterized wastes include those contained in the quarry. Figure 2-3 depicts the principal contaminated areas at the Weldon Spring site.

The overall waste management program for the WSSRAP, as required by DOE Order 5820.2A, is described in the *Waste Management Plan* (Ref. 27). The Waste Inventory/Tracking System (WITS) is an electronic database that is used to provide an automated method of tracking waste at the site. WITS is used to determine safe storage, handling, sampling and shipping requirements, as well as to provide the means for compliance reporting and containerized waste assessment. The *Waste Quantities Quarterly Report* provides the official WSSRAP base inventory of waste material on a quarterly basis. Engineering calculations and designs must always reference the specific *Waste Quantities Quarterly Report* in effect at the time calculations or designs are developed.

The balance of the available information for site wastes and contaminated media can generally be described in terms of physical, chemical, and radioactive data.

2.3.3.1 Physical Characterization Data. Wastes present in the quarry consist of a heterogeneous mixture of rubble, soils, sediments or sludges, and interstitial water. Rubble consists of concrete and steel building materials, drums, and process equipment. Many of the drums are ruptured and corroded. The *Remedial Investigations for Quarry Bulk Wastes* (Ref. 28) and the *Feasibility Study for Management of the Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri* (Ref. 29) summarizes additional information regarding the physical characteristics of quarry wastes.

The chemical plant has been extensively characterized and a considerable amount of data exist regarding the physical nature of wastes. Waste forms at the chemical plant are similar to those for the quarry, and include contaminated soil, sludge, sediment, concrete and steel building materials, drums, and process equipment. The *Remedial Investigation for the Chemical Plant Area of the Weldon Spring Site* (Ref. 4) and the *Feasibility Study for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 1) provide additional descriptions of the physical characteristics of wastes at the chemical plant site. Table 2-1 provides estimates of the volume of contaminated material addressed by the remedial action for the chemical plant area.

With the exception of percent solids analyses for some of the containerized wastes in the process buildings, Building 434, and the TBP tanks, physical data for wastes at the chemical plant primarily pertains to the raffinate sludge and contaminated soils. These data include, unit weight, specific gravity, percent water, particle-size analysis (sieve and hydrometer), consolidation, Harvard miniature compaction, Atterberg limits, permeability, capillary-moisture

relationship, loss on ignition, viscosity, filtration, centrifuge, response to vibration, electrical resistivity, specific yield, electron micrography and flocculation-settling tests that were performed. The *WSSRAP/FEMP Data Review and Comparison Report* (Ref. 30) provides a summary of the physical test results performed on raffinate sludges and additional data sources.

Additional physical data for site soils are contained in the *WSSRAP Chemical Plant Geotechnical Investigations* (Ref. 17) and the *WSSRAP Disposal Facility Geotechnical Characterization Report* (Ref. 18). These data include standard penetration, California Bearing ratio, in situ unit weight, percent moisture, particle-size analysis, Atterberg limits, specific gravity, standard Proctor compaction, consolidation, triaxial compression, and in situ and laboratory permeability tests results.

2.3.3.2 **Chemical Characterization Data**. Chemical characterization of WSSRAP wastes includes analyses of containerized wastes, raffinate sludge, and quarry and site soils. Analytes include organic and inorganics comprising the EPA contract laboratory program (CLP) list, nitroaromatics covered by the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) analytical methods, and other analytes and methods specific to site wastes (e.g., RCRA characteristics, pH, nitrate/nitrite, sulfate, chloride, flouride, sodium, metal oxides, mineralogy, and others).

Chemical characteristics for the quarry wastes have not been determined to a high degree of confidence, due to the largely heterogeneous and inaccessible nature of the waste pile, and should be regarded as preliminary. Chemical characteristics of the quarry bulk wastes as reported by the *Remedial Investigations for the Quarry Bulk Wastes* (Ref. 28) and the *Feasibility Study for Management of the Bulk Wastes at the Weldon Spring Quarry* (Ref. 29) are consistent with the disposal history of the site and includes nitroaromatic compounds, polychlorinated biphenyls (PCBs), polycyclic (or polynuclear) aromatic hydrocarbons (PAHs) and metals. Most of the characterization of the quarry wastes will be performed during their excavation and removal activities. Chemical characterization data for containerized wastes is kept in the Waste Management Department's waste analyses file.

Nonradioactive chemicals, such as nitroaromatic compounds, heavy metals, strong acid salts, and other organic compounds are present at the site as a result of trinitrotoluene (TNT) production and uranium processing activities. Additionally, contaminants such as PCBs and asbestos are present because of previous uses of equipment and buildings on site. The *Remedial*

Investigation for the Chemical Plant Area of the Weldon Spring Site (Ref. 4) and the *Feasibility Study for Remedial Action At the Chemical Plant Area of the Weldon Spring Site* (Ref. 1) provide detailed discussions of the chemical characteristics of wastes present at the chemical plant, with the exception of those wastes stored in Building 434. References containing analytical data for raffinate sludges and site soils are summarized in the *WSSRAP/FEMP Data Review and Comparison Report* (Ref. 30).

2.3.3.3 **Radiological Characterization Data.** Radiological characterization of WSSRAP wastes includes isotopic analyses of containerized wastes, raffinate sludge, and quarry and site soils. Radioisotopic analyses which have been performed include total uranium, U-234, U-235, U-238, Th-228, Th-230, Th-232, Ra-226, Ra-228, Pb-210, and Po-210. Much of the available radiological data for site soils was appraised using the site radiological laboratory which utilizes a high-purity germanium detector. Resulting data are summarized in reports or stored in hard copy files. Chronological logs of analytical runs are maintained on site for the chemical plant, quarry,and vicinity properties. The site radiological laboratory also maintains a kinetic phosphorescence analyzer (KPA) for determinations of uranium in water samples.

The greatest quantity of contamination in the quarry bulk waste is radiological. Most of the quarry bulk waste is known to contain above background concentrations of U-238, Th-232, and daughter radionuclides of the uranium and thorium decay series. A detailed discussion of the radiological characteristics of the quarry bulk wastes is provided in the *Remedial Investigations for Quarry Bulk Wastes* (Ref. 28) and the *Feasibility Study for the Management of the Bulk Wastes at the Weldon Spring Quarry* (Ref. 29). The *WSSRAP/FEMP Data Review and Comparison Report* (Ref. 30) is a comprehensive summary of characterization and treatability studies of raffinate pit sludges for the Weldon Spring site.

2.3.4 Waste Treatment Data

Waste treatment data generated with respect to WSSRAP wastes include chemical stabilization/solidification (CSS) and vitrification bench scale testing results. Much of the physical, chemical, and radiological characterization data discussed above was generated in conjunction with bench-scale treatability studies. Treatability studies have been limited to testing raffinate sludge and site and quarry soils.

Due to ongoing characterization of WSSRAP containerized wastes, their variety, and applicable best demonstrated available technology (BDATs), treatability testing of the containerized wastes has not yet been performed. However, Sections 5.3.7 and 6.3.7 provides a listing of the types of containerized wastes and alternative treatment technologies considered.

2.3.4.1 Chemical Stabilization/Solidification. CSS testing of raffinate sludge and soils from the site and quarry includes percent moisture/water, strength (penetrometer resistance and unconfined compressive strength), free liquids/paint filter, compaction, and leachable (toxicity characteristic leaching procedure [TCLP] and ANSI 16.1) contaminant testing. References that contain CSS treatability results for raffinate sludge and site and quarry soils include: *Weldon Springs Raffinate Pits: Evaluation of Cement-Based Grouts as a Stabilization Option* (Ref. 31); *Stabilization/Solidification Testing of Raffinate Pit Sludges and Nitroaromatic Soils* (Ref. 32); and *Comprehensive Analytical Results of On-Site CSS Testing* (Enger March 10, 1993, Appendix A). Current investigations will provide data on leachability of different waste forms and on interactions of leachates with subsurface and liner soils.

2.3.4.2 Vitrification. In situ and crucible bench-scale vitrification treatability tests were performed using raffinate sludge and site soil. Power consumption, temperature, viscosity, off-gas, and volume change were monitored or measured as part of the tests. Total and leachable contaminant analyses were also performed in conjunction with the vitrification bench scale testing. The following references contain WSSRAP specific vitrification test results: *Vitrification Technologies for Weldon Spring Raffinate Sludges and Contaminated Soils, Phase II Report: Screening of Alternatives* (Ref. 34); and *Development of a Combined Soil Wash/In-Furnace Vitrification System for Soil Remediation at DOE Sites* (unpublished research by Duratek Corp., Catholic University of America, Westinghouse Science and Technology Center) (Ref. 33).

TABLE OF CONTENTS

NUMBER PAGE

3 CONCEPTUAL DESIGN METHODOLOGY 3-1

3.1 General 3-1
3.2 Design Activity Definition 3-2

3.2.1 Review Base of Information 3-2
3.2.2 Functional Requirements 3-3
3.2.3 Performance Requirements 3-3

3.3 Identification of Alternatives 3-3
3.4 Evaluation of Alternatives 3-4
3.5 Selection of Preferred Alternative 3-4
3.6 Detail of Preferred Alternative 3-5
3.7 Technical Uncertainties 3-5
3.8 Operational Requirements 3-6

3 CONCEPTUAL DESIGN METHODOLOGY

3.1 General

The conceptual design methodology consisted of a logical sequence of activities intended to assist the design engineer in selecting the conceptual design. The process began with a review of base documents. The design engineer continued by:

- Defining the functional and performance requirements.
- Identifying the feasible alternatives.
- Evaluating these alternatives.
- Selecting a preferred alternative.
- Detailing the preferred alternative.
- Identifying uncertainties and proposing solutions.
- Identifying data needs for subsequent detailed studies.
- Presenting the operational requirements associated with the selected design.

This methodology was implemented to produce a consistent and well documented record of decisions that led to the various designs in the Technical Information Document (TID). Consistency is achieved because the numerous design tasks in the TID followed the same methodology. The assessment process results are documented by sheets produced in modified value engineering (MVE) sessions. MVEs provided a standard to select a preferred alternative design; this procedure is described in Subsection 3.4. By clearly defining the methodology and sequence, the design engineer is assured of a reasonable confidence in the selected design. This method provides a record of step-by-step decisions that can be easily traced in case of subsequent changes in remediation practices, scopes, or other criteria that demand a different or modified detailed design. In addition, the complex relationship and overlap with other remediation design components is also identified in this methodology. This facilitates the analysis of the system-wide designs and activities and encourages the design engineer to discuss such a systems analysis. This logical and prudent engineering practice conforms with DOE Order 4700 in preparing the *Conceptual Design Report* (CDR). It should be noted, however, that certain activities do not readily lend themselves to the MVE process. These activities are those that have already been determined by previous detailed studies, those that have performance requirements limited to such an extent by other activities that all but one feasible alternative are eliminated, and those activities judged minor in comparison to the cleanup action. Therefore,

certain features or activities of the design components presented in Sections 5 and 6 of this TID may not have used the MVE process.

3.2 Design Activity Definition

The various designs addressed in the TID follow the methodology presented in Section 3.1 and are divided in three general topics: general site designs, disposal cell designs, and treatment and processing methods. General site designs are those designs related to activities that support the construction of the disposal cell and the treatment of the waste. Disposal cell designs are associated only with the cell components, including waste placement. Waste treatment methods include those designs associated with the various waste treatment processes.

In addition, sections on site closure, long term monitoring and maintenance, and cell performance are also included in the TID; the latter topic did not require the presentation of designs, only an assessment of the proposed conceptual cell design.

3.2.1 Review Base of Information

The first step of the design methodology is the review of information related to the overall remediation program, procedures, and especially data related to the particular design. This may include a brief overview of previous studies, the identification of gaps in data or supporting studies, and a review of ongoing investigations that may have an impact in the conceptual design. These ongoing studies include the supporting studies that commenced prior to the conceptual design efforts with the intent of providing information to the various design tasks. The design engineer uses this review to achieve the necessary familiarization and comprehension of the Weldon Spring remediation program, thus ensuring the integration of base information and concepts into the CDR. The *Remedial Investigation* (RI) (Ref.4) and the *Feasibility Study* (FS) (Ref.1) are two key documents in this review because they define the remediation program at the Weldon Spring site and set the bases for the conceptual design; these documents are listed in Section 3.2 and Appendix B of the *Scoping Document* (Ref. 5). Other documents listed in this appendix were also reviewed. The data base presented in Section 2 was reviewed to identify the type and amount information available.

3.2.2 Functional Requirements

A primary stage of the conceptual design, as identified in DOE Order 4700, is the identification of the functions of the proposed design. This process relates to the understanding of the overall remediation program and demands that the author (design engineer) present the function/purpose of a specific design. A description of the design function is necessary to show how it and other tasks meet the system requirements. The functional requirements section of each design describes how the physical systems and processes meet the design criteria. Block and flow diagrams may be included to show the relationships of systems.

3.2.3 Performance Requirements

In addition to describing the function of each design, the performance must also be assessed. These performance requirements will quantify reliability, availability, and maintainability of the design or operation related to the design. Some of the performance requirements include acceptable tolerances or ranges. Examples of these include vehicle loads for site access roads, compaction criteria for the cell foundation, maximum capacity for drainage structures.

The performance parameters control the conceptual designs, especially if these parameters were determined from measured data or acceptable industry standards. Many of these parameters are determined after quantifying system input or output requirements and identifying and specifying the various process variables. It is conceivable that the performance requirements are determined from the systems analysis, especially if the input to a specific design is derived from the output of another. This is particularly applicable to the excavation, treatment, and placement of the waste in the disposal cell, because each of these designs is dependent on the other.

3.3 Identification of Alternatives

Once the design function is understood and the performance requirements are established, the basis for the design is complete. The selection process of a design follows. This step in the methodology consists of identifying the feasible design alternatives. The objective is to list all the alternatives that should be considered that meet the functional and performance requirements.

If the number of feasible alternatives appears to be too great, an MVE session narrows this number to less than 10. The functional and performance requirements help to reduce the alternatives to a manageable number, preferably five or less. There will be cases, however, when the number of alternatives is limited to no more than two or three. Some objectivity is required by the designer in defining the concept of "feasibility," and thus, feasible alternatives. This is where the review of previous reports and a good understanding of the remediation program (Section 3.2.1, Review Base of Information) plays a key role in the design process.

3.4 Evaluation of Alternatives

The evaluation of the identified feasible alternatives is performed at this stage of the methodology. The purpose is to determine which of the alternatives best meets a previously identified list of criteria. These criteria are developed to correlate and evaluate the alternatives. The remediation program has defined some of these criteria such as protective of human health and the environment, able to meet remediation schedule, proven or best developed available technology; other criteria more specific to the task may be added to this list, such as able to meet a certain throughput, achieve a desired consistency, eliminate double handling, and many others. These criteria are used in MVE sessions to select an alternative based on a point value system. It is conceivable that two alternative designs could be selected that are equal in point value and a less critical criteria, such as cost, would then be used to select one. The results of the MVE are documented in a table like the one shown in Table 3-1.

MVE sessions provided a means for the designer to evaluate all alternatives on an equal basis (the criteria), allows for input from other designers and thus other perspectives, and finally provides the documentation that could be used to trace the decision process at a future date. Part of the MVE documentation allows designers and reviewers an opportunity to follow the reasoning for choosing a specific design.

3.5 Selection of Preferred Alternative

The result of the MVE session on the various alternatives is the selection of the preferred alternative. Components or appurtenances of the selected design may also have been selected through the use of MVE sessions.

The selected alternative is based on the criteria that were used to evaluate all of the alternatives; therefore, the criteria should be screened for applicability, adequacy, appropriateness to Weldon Spring, and factors that must be considered in the evaluation process. The preferred alternative must meet these criteria and the functional and performance requirements.

3.6 Detail of Preferred Alternative

Once the preferred alternative is selected it needs to be detailed. Such detail provides the information specific to the alternative; it explains the design, the components, the interphase with other designs, the parameters that can be varied to meet throughput or possible deviations, the processes, and other detailed information within the conceptual scope of work. Ranges of values can be assigned in order to allow for subsequent modifications in final design. Part of this detail includes providing figures or drawings to assist in the explanation of the design or the process.

The operational aspects of the selected design are discussed in Section 6. If there are alternatives to these operations, then the conceptual design methodology is applicable to the operations as well.

3.7 Technical Uncertainties

Technical uncertainties associated with the design or operational elements will be identified. The cause of the uncertainty will be mentioned, and if feasible, the solution or process for eliminating or decreasing this unknown. In order to deal with the uncertainties that affect the design, the observational approach will be used whenever feasible. A table titled Observational Method lists the potential deviations to the expected design or operation and the consequential affects are identified. An example of this table is shown in Table 3-2. In addition, another table titled Data Quality Objectives provides for the identification of data gaps that need to be filled prior to Title II design. This table is presented in Table 3-3 .

3.8 Operational Requirements

Each conceptual design discussed in the TID has an associated operation. These operations are discussed in Section 6. The conceptual design methodology for selecting an alternative also applies if there are a number of operations that can be implemented.

TABLE OF CONTENTS

NUMBER PAGE

4 BASIS FOR CONCEPTUAL DESIGN 4-1

4.1 General 4-1
4.2 Regulatory Requirements and Issues 4-1

4.2.1 General Regulatory Requirements 4-2
4.2.2 NEPA Regulations 4-2
4.2.3 Applicable or Relevant and Appropriate Requirements for the Conceptual Designs 4-3

4.2.3.1 General Site Design 4-4
4.2.3.2 Disposal Facility 4-10
4.2.3.3 Treatment and Processing 4-19
4.2.3.4 Site Closure 4-26
4.2.3.5 Long-Term Monitoring and Maintenance 4-28

4.3 Environmental Safety and Health Issues 4-28

4.3.1 Contaminant Concentrations In Source Areas 4-29
4.3.2 Worker Exposure Limits 4-31
4.3.3 Construction Safety 4-32
4.3.4 Personal Protective Equipment Requirements 4-32
4.3.5 Engineering Controls 4-33
4.3.6 Contamination Controls 4-33
4.3.7 Monitoring Requirements 4-35
4.3.8 Contingency Plans 4-35

4.4 Quality Assurance 4-36

4.4.1 Quality Assurance Program 4-37

TABLE OF CONTENTS (Continued)

NUMBER PAGE

4.4.2 Personnel Training and Qualification 4-37
4.4.3 Documents and Records 4-38
4.4.4 Design 4-38
4.4.5 Procurement 4-38
4.4.6 Inspection and Acceptance Testing 4-38
4.4.7 Management Assessment 4-39
4.4.8 Environmental Quality Assurance Project Plan 4-39

4 BASIS FOR CONCEPTUAL DESIGN

4.1 General

The basis of conceptual design as it relates to regulatory requirements, environmental safety and health, and quality assurance is described in the following sections. All designs have been selected with respect to the mandated and applicable requirements established under both State and Federal agencies. Design and operational considerations, along with construction requirements, are addressed in a basic framework which will be further defined and detailed in Title II designs and specifications.

4.2 Regulatory Requirements and Issues

Section 121(d) of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), as amended by the *Superfund Amendments and Reauthorization Act* (SARA), requires that remedial actions attain a specified degree of cleanup of hazardous substances, pollutants, and contaminants. Requirements for the remedial actions performed in a cleanup must be legally applicable or relevant and appropriate for the release or threatened release of a substance, pollutant, or contaminant. CERCLA also requires that remedies must protect human health and the environment, be cost-effective, and use permanent solutions and alternate treatment technologies to the maximum extent possible.

Federal, State, and local laws and regulations may contain applicable or relevant and appropriate requirements (ARARs) for a remedial action. Those requirements in nonpromulgated advisories or guidance that are not legally binding may, however, be considered in establishing cleanup goals. These nonbinding requirements are called "to-be-considered" (TBC) requirements. Site cleanup goals in U.S. Department of Energy (DOE) Orders are classified as TBCs for remedial actions at the Weldon Spring Site Remedial Action Project (WSSRAP). The ARARs and TBCs for the land disposal facility are discussed in this section.

The agencies involved in identifying and approving ARARs for remedial actions at the WSSRAP are the U.S. Environmental Protection Agency, Region VII, Missouri Department of Natural Resources, and the U.S. Department of Energy. Other agencies consulted are the Missouri Department of Conservation, the U.S. Army Corps of Engineers, the U.S. Fish and

Wildlife Service, the Missouri Highway Department, the Soil Conservation Service, and the Federal Emergency Management Agency (maps).

4.2.1 General Regulatory Requirements

The treatment and subsequent disposal of WSSRAP wastes in an engineered cell is the preferred, final remedial action at the WSSRAP according to the *Record of Decision* (ROD) (Ref 3). Final ARAR cleanup goals have been identified in the Remedial Investigation/ Feasibility Study (RI/FS) documentation process and are finalized in the ROD. Specific components of the final remedial action will address the disposition of (1) quarry nitroaromatic soils; (2) quarry bulk wastes; (3) vicinity properties and site sediment, sludge, soil, vegetation; (4) demolition debris; (5) Building 434 - containerized chemicals; (6) water treatment plant process waste; and (7) quarry residual soil and sediment. The following sections will discuss the ARARs for the above components, as well as the construction of the disposal cell.

4.2.2 NEPA Regulations

Cleanup actions at the Weldon Spring site are being conducted under the requirements of the CERCLA, as the site is listed on the National Priorities List (NPL). However, because the DOE is the lead agency, the actions must also comply with the *National Environmental Policy Act* (NEPA) implementing procedures as found in 10 CFR 1021. SEN-15-90 and DOE Order 5440.1E also contain NEPA guidance and requirements. In fact, the DOE is very clear concerning the integration of the CERCLA and the NEPA in DOE Order 5400.4, *Comprehensive Environmental Response, Compensation, and Liability Act Requirements*, which states:

> "Where DOE remedial actions under CERCLA trigger the procedures set forth in NEPA, it is the policy of DOE to integrate the procedural and documentation requirements of CERCLA and NEPA, wherever practical. The primary instrument for this integration will be the RI/FS process....In addition, the public review processes of CERCLA and NEPA will be combined for RI/FS-NEPA documents, where appropriate."

NEPA requires that an environmental assessment (EA) be prepared to determine whether an *Environmental Impact Statement* (EIS) or a finding of no significant impact (FONSI) is required for a proposed action. Those major Federal actions that significantly affect the quality of the

human environment require an EIS. Proposed actions that do not individually or cumulatively have a significant effect on the quality of the human environment and are not otherwise addressed in an EA or EIS are documented as a categorical exclusion (CX).

The integration of the procedural and documentational requirements of NEPA and CERCLA at remedial action sites will minimize the preparation of duplicate documentation, support consistent decisions, and facilitate timely cleanup. The NEPA documentation process (i.e., EA, EIS, CX) is integrated with the CERCLA documentation process (e.g., RI/FS) at the WSSRAP. The RI/FS-EIS for the chemical plant operable unit incorporates those elements of an EIS under NEPA that are not explicitly included in an FS under the CERCLA. In addition to the RI and FS documents, the baseline assessment (BA), which evaluates potential health risks and environmental impacts that could occur if no cleanup action were taken, and the proposed plan, which highlights information from the FS and identifies the preferred alternative, comprise the integrated RI\FS-EIS package.

Activities supporting the remedial action that are not otherwise covered in a CERCLA/NEPA document may require EA or CX documentation under DOE's regulations for NEPA compliance. An example of an activity that would be supported with an EA and FONSI is the excavation of clay soils at the borrow source area for use as borrow material in construction of the disposal cell. Examples of CX-type activities are small removal actions not otherwise addressed in site documents, site characterization activities, and construction of additional office space.

4.2.3 Applicable or Relevant and Appropriate Requirements for the Conceptual Designs

This section discusses the CERCLA ARARs as they relate to various parts of the conceptual design. The remedial action ARARs from the ROD have been incorporated into the appropriate subparts of this section. To assist the designers, this section is patterned after Sections 5 and 6. Subparts of Sections 5 and 6 have specific regulatory information; this section consolidates the regulatory information in Sections 5 and 6, as well as the ROD discussion.

In general, each subpart of Section 4.3 contains the design and operating ARARs. The design requirements are followed by the operating requirements, but are not designated as such because certain requirements fall under both.

Some worker and public protection requirements (i.e., Occupational Safety and Health Administration (OSHA) and DOE Orders) are included in the following subparts; however, the discussion is not complete since no construction standards are provided. Neither worker/public protection requirements nor construction standards are CERCLA ARARs, because ARARs are environmental requirements.

4.2.3.1 General Site Design. This section encompasses various tasks and facilities in support of the disposal cell and site water treatment plant (SWTP) as follows: soil removal, waste handling and transportation, the construction materials staging area (CMSA), site roads, site drainage, borrow material, and support facilities. Because these are miscellaneous functions and support facilities, few environmental regulatory requirements are pertinent. The following discussion only addresses those areas for which a number of environmental regulations apply.

Waste Removal

Contaminated soil will be removed from various locations at the chemical plant and vicinity properties. Very few regulatory standards exist for soil clean-up criteria; therefore, site-specific criteria were developed for the soils based on ARARs, site-specific risk information, and an application of the DOE's policy to reduce levels as low as reasonably achievable (ALARA), as specified in DOE Order 5400.5, Chapter II. Section 2 of the *Feasibility Study for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 1) contains a discussion of the soil cleanup criteria. The ROD then finalizes the cleanup criteria; these are presented in Table 4.2.1. These soil cleanup criteria also apply to the waste sludge and the vicinity property soils.

Uranium Mill Tailings Remediation Control Act (UMTRCA) standards in 40 CFR 192, Subpart B address residual concentration levels of Ra-226 in soil. Residual levels should not exceed background by more than 5 pCi/g in the top 15 cm of soil or 15 pCi/g in each 15 cm layer below the top layer, averaged over an area of 100 m^2. These levels are incorporated into the site soil cleanup criteria.

State regulation 10 CSR 10-6.170 restricts emission of particulate matter to the ambient air such that the particulate matter may not go beyond the premises of origin in quantities that remain visible in the ambient air or that may be found on surfaces beyond the property line of

origin. Removal activities must prevent visible particulate matter from going beyond site boundaries using dust control measures.

Federal regulations 40 CFR 264 and 268 are applicable to all *Resource Conservation Recovery Act* (RCRA) characteristic soils. Any soils that contain a hazardous characteristic must be handled, stored and treated as a hazardous waste. However, the restrictions on placement activities of hazardous waste prior to placement in the disposal cell are waived in the ROD (40 CFR 268 Subpart C). Examples of placement activities are placing sludge into a sedimentation tank or size separator before treatment or other movements of waste from one on-site area to another prior to treatment.

Federal regulation 29 CFR 1926, Subpart P, sets forth requirements for open excavations. Requirements include access and egress, warning systems for mobile equipment, protection of employees, and shoring and piling support.

Pertinent requirements from the following DOE Orders will also be complied with under this task:

- DOE Order 5400.5, *Radiation Protection of the Environment*, Chapter II, "Requirements for Radiation Protection of the Public and the Environment," and Chapter III, "Derived Concentration Guides for Air and Water."

- DOE Order 5480.11, *Radiation Protection for Occupational Workers*.

- DOE Order 5820 2A, *Radioactive Waste Management*, Chapter III, "Management of Low-Level Waste" and Chapter IV, "Management of Waste Containing Byproduct Material and Naturally Occurring and Accelerator Produced Radioactive Material."

Waste Handling and Transportation

This activity involves the handling and transportation of all waste, both on site and from vicinity properties. On-site waste may be transferred from the original waste location to an interim storage location, a treatment plant, or placed directly into the disposal cell (i.e., all waste transfers will take place before deposition in the cell). The waste may contain chemical, radioactive, or asbestos contamination. Therefore, the regulations governing waste handling are

the National Emission Standards for Hazardous Air Pollutants (NESHAPs) for asbestos (40 CFR 61 Subpart M), State emission regulations, and DOE Orders. In addition, RCRA and U.S. Department of Transportation (DOT) regulations may apply to the transfer of vicinity soils.

Any asbestos contaminated material will be placed in storage until a decision is made for final deposition in the cell. Friable asbestos will be bagged and labeled. Transfer of bagged asbestos must ensure that the bags do not become punctured.

The temporary storage area (TSA) may contain asbestos contaminated soil from the quarry. This soil must be transferred so that no visible emission is allowed. The soil should be wetted and placed into wind-tight roll-offs or other type containers.

Nonfriable asbestos must be handled such that the asbestos does not become friable (crumbled, pulverized, or reduced to powder). An example of nonfriable asbestos-contaminated material is building roofing stored at the Ash Pond area.

Any asbestos contaminated soil from vicinity properties must be transferred in wind-tight containers such as roll-off boxes. The haul trucks must be properly marked and accompanied by a waste transfer form.

The State radon emission limit of 1 pCi/l (19 CSR 20) above background (quarterly average) in uncontrolled areas has been waived in the ROD for certain on-site, pre-disposal activities. This limit should be considered the goal to meet at all property boundaries. All vicinity properties waste removal, handling, and transfer activities must meet the above limit to ensure radiation protection of the workers and the public.

State particulate standards (10 CSR 10-5.180) for internal combustion engines (no release for more than 10 seconds at one time) are applicable to particulate release from any internal combustion engines used during waste handling and transportation. In addition, 10 CSR 10-6.170 restricts particulate matter to the ambient air beyond the property boundary.

Contaminated soil/waste from vicinity properties must be transported in accordance with the DOT regulations. Specific requirements for packaging, marking, labeling, placarding, and manifests will depend on the type of waste or contamination and the quantity to be transferred.

If any vicinity property soils contain a RCRA constituent, RCRA manifest regulations will be applicable.

Construction Material Staging Area

Storm water runoff at the CMSA will be regulated by the National Pollutant Discharge Elimination System (NPDES) program. The CMSA will be a clean area, but will be constructed in an area that is currently contaminated; therefore, storm water outfalls from the CMSA will be added to the existing NPDES permit, MO-0107701. In addition, construction permits will be required for CMSA sedimentation basins.

Site Roads

Three Missouri regulatory requirements must be considered in the design and operation of site roads. State regulation 10 CSR 10-5.310 states that there shall be no direct application of liquified cutback asphalt on highways, roads, parking lots and driveways from April through October. Regulation 10 CSR 10-6.170 provides restrictions of particulate matter to the ambient air such that the particulate matter may not go beyond the premises of origin in quantities that remain visible in the ambient air or may be found on surfaces beyond the property line of origin. Another requirement (10 CSR 25-11.010) states that oil cannot be used for dust suppression.

Site Drainage

All surface water discharges are controlled under a surface water management program, which is carried out in accordance with permits issued under the NPDES program. The design, construction, and operation of site sedimentation/detention basins must comply with the *Surface Water Management Plan* (Ref. 36). The NPDES permit specifically limits discharge of total settleable solids to 1.0 ml/hour (during remedial action).

In addition, all surface water discharges will meet the requirements set forth in DOE Order 5400.5, *Radiation Protection of the Environment*, Chapter II, "Requirements for Radiation Protection of the Public and the Environment," and Chapter III, "Derived Concentration Guides for Air and Water." Specifically, all surface water discharges must not exceed the average annual limit of 600 pCi/l for uranium.

Borrow Material

The borrow source area will provide the proper type and amount of clay soil required for foundation removals and for liner and cover material for the disposal cell. The requirements for the disposal cell liner and cover material are found in Section 4.2.3.2, Disposal Facility, below.

Other Facilities

Other facilities are those site facilities that already exist, are being designed or constructed, or are being proposed. "Other facilities" are any facilities or processes required to support remedial action activities at the Weldon Spring site that are not directly related to the construction of the disposal cell and the associated waste treatment facilities. Examples include power, water and sewer utilities, laboratory facilities, leachate storage and treatment facilities, dust control facilities, parking lots, and access control. As none of these facilities are directly related to waste removal, treatment, or disposal, few environmental laws apply.

Building 434 stores RCRA and *Toxic Substance Control Act* (TSCA) materials. Therefore, this facility is regulated under both 40 CFR 264, which includes storage and inspection requirements, types of approved containers, and special requirements for ignitable, reactive or incompatible wastes; and 40 CFR 761, Subpart D, which sets forth storage facility criteria and lists storage requirements such as approved containers and inspection schedules.

Borrow Source Area

The proposed borrow source is located on Department of Conservation land east of State Route 94, approximately 2 mi from the site. Borrow source operations will include excavating approximately 1.0 to 1.5 million cu yd of clay material, for disposal cell construction. This material will be transported along a dedicated haul road to the site.

Because the clay source area is off site, the following acts apply: the *National Historic Preservation Act*, the *Archeological and Historic Preservation Act*, the *Archeological Resources Protection Act* and Section 404 of the *Clean Water Act*. The *National Historic Preservation Act* states that the effect of any Federally assisted undertaking should be taken into account for any district, site, building, structure, or object included in or eligible for the *National Register of*

Historic Places. The *Archeological and Historic Preservation Act* requires that data recovery and preservation activities be conducted if prehistoric, historical, and archeological data might be destroyed as a result of a Federal activity. A permit is required to excavate or remove any archeological resources from Federal lands under the *Archeological Resources Protection Act*. Studies are being performed to determine if any archeological sites or resources will be affected in the borrow area, and whether any resources would be removed before soil is excavated. A permit would be obtained by the Project Management Contractor (PMC) for removal of any archeological resources in the borrow area.

Executive Order 11990 requires Federal agencies to avoid, to the extent possible, any adverse impacts on wetland areas. This Order is considered applicable as the potential off-site borrow area may affect wetlands. Mitigative measures are being coordinated with the State of Missouri and will be defined in a mitigation action plan. These measures may include contouring to ensure that downgradient wetlands are not indirectly impacted, and the creation of wetlands in the borrow area or nearby areas. A Section 404 *Clean Water Act* permit and/or Nationwide permit will be obtained by the PMC from the U.S. Army Corps of Engineers due to the wetland activities at the borrow area.

The *Farmland Protection Policy Act* (7 CFR 658) requires Federal agencies to assess the adverse impacts of Federal programs on farmland preservation and to consider alternative actions to lessen the adverse effects. This requirement is considered applicable to the off-site soil borrow area. A separate environmental assessment is planned for the borrow area to assess possible environmental impacts. Mitigation measures and restoration activities would be conducted, as necessary, to minimize any adverse impacts to farmland.

The *Land Reclaration Act* (10 CSR 40-10.010) require a Land Reclamation Permit from the Land Reclamation Commission prior to surface mining of industrial minerals, including clay. However, a permit is not required of a governmental agency whose operations comply with the reclamation standards in RSMo. 444.774 and that registers with the Land Reclamation Commission prior to operations. The borrow area action will comply with the reclamation standards for post-mining use, backfilling and grading, sediment and water management control, and protection of adjacent properties (as specified in 10 CSR 40-10.050) and will be registered with the commission.

The *Clean Water Act* requires an NPDES permit, which will be obtained by the PMC, for storm water discharges associated with industrial activities from construction sites involving the excavation or grading of 5 acres or more. This requirement is considered applicable to the borrow area because the extent of excavation at the borrow area is estimated at approximately 95 acres. Included as part of the permit process is a water pollution prevention plan, which will be prepared for the borrow area and which will include preventative measures for erosion control.

OSHA regulations in 29 CFR 1910.95 establish occupational noise exposure standards. This standard states that employees shall be protected against noise exposure above the permissible levels (i.e., 80 dBA for an 8-hour day). Administrative or engineering controls shall be implemented if exposure exceeds the levels set forth in the standard. This requirement is applicable to the borrow area excavation operations where heavy equipment will be used.

Several State air quality standards apply to the borrow source activities. State regulation 10 CSR 10-5.180 provides particulate standards for internal combustion engines. This regulation states that there will be no visible emission of air contaminants from any internal combustion engine for more than 10 consecutive seconds at any one time. State regulation 10 CSR 10-5.310 states that there shall be no direct application of liquified cutback asphalt on highways, roads, parking lots and driveways from April through October. Regulation 10 CSR 10-6.170 restricts the release of particulate matter to the ambient air so that the particulate matter may not go beyond the premises of origin in quantities that remain visible in the ambient air or may be found on surfaces beyond the property line of origin. State regulation 10 CSR 25-11.010 states that oil cannot be used for dust suppression.

4.2.3.2 Disposal Facility. The primary environmental laws that pertain to the design and operation of a newly-constructed disposal facility are the *Solid Waste Disposal Act*, the *Resource Conservation and Recovery Act*, the *Toxic Substance Control Act*, the Missouri Hazardous and Solid Waste Management Laws, and the *Uranium Mill Tailings Radiation Control Act*. None of these laws apply to the combination of wastes to be disposed of; however, aspects from each are relevant and appropriate to activities included in the design, construction, and operation of the disposal facility.

While the RCRA requirements are not considered applicable to disposal operations (the characteristic waste will be treated to below hazardous levels prior to placement), many are

considered to be relevant and appropriate based primarily on the purpose of the requirements and the nature of the actions. The disposal facility shall comply with the substantive requirements of the TSCA with the exception of 40 CFR 761.75(b)(3), which states the bottom landfill liner system or natural in-place soil barrier shall be at least 50 ft (17m) from the historical high water table. The volumes of TSCA wastes are expected to be limited, and any wastes containing greater than 50 ppm of PCBs will either be managed separately or the above requirement will be waived in the ROD to allow disposal in the cell. Consequently, the RCRA and UMTRCA requirements are the primary ARARs for cell construction and operation activities.

For purpose of analysis, the disposal requirements of these laws and their corresponding regulations can be grouped into the following categories: buffer zone requirements, siting requirements, cover requirements, and liner/leachate collection system requirements. Cell closure and monitoring and maintenance are discussed separately in Sections 4.3.4 and 4.3.5, respectively.

Buffer Zone

Because there are no buffer zone requirements in TSCA or UMTRCA, only the Missouri Solid Waste Regulation (10 CSR 80-3.010) that requires a buffer of 50 ft, is relevant and appropriate. Missouri Hazardous Waste Regulation, (10 CSR 25-7.264) which requires a 300-ft buffer is not applicable but is relevant and appropriate. The intent of the buffer zone, besides ensuring that the public will not come into contact with the cell or its contents, is to allow adequate easement for operations, maintenance, and monitoring. Conceptual design may proceed on the basis of a 300 ft buffer from the toe of the cell side slope, hypothetically assuming a typical 3 horizontal:1 vertical RCRA slope.

To provide an additional safeguard, the DOE may attempt to acquire a small parcel of adjacent land from the Missouri Department of Conservation to extend the buffer zone to the degree practicable.

Siting

Location standards are specified under the RCRA (40 CFR 264.18) that address the siting of new hazardous waste treatment, storage, and disposal facilities. Because the treatment

process will render the characteristic waste nonhazardous and no listed waste will be disposed of on site, these requirements are not considered applicable to the disposal facility. There are, however, certain requirements that are considered relevant and appropriate to the disposal facility. These requirements, as well the companion requirements in the Missouri Hazardous Waste Management Law, are described below.

- 40 CFR 264.18(a) restricts locating hazardous waste management facilities within 200 ft of a fault that has been displaced in Holocene time. This requirement is intended to minimize the chances of catastrophic failure resulting from an earthquake.

- 40 CFR 264.18(b) restricts locating hazardous waste management facilities within a 100-year floodplain. This requirement is intended to prevent the spreading of contaminants during extreme flooding conditions.

- 10 CSR 25-7.264(2)(N)1.A(iii)(a) provides siting criteria for new hazardous waste landfills that identify a requirement for 30 ft of soil or other material with a permeability of $1x10^{-7}$ cm/s or an equivalent protection based on at least 20 ft of naturally occurring material for a landfill that receives only waste generated by the operator. Site conditions generally meet above criteria and must be retained by using engineered fill. The argument supporting this determination is found in the *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 3).

  The disposal cell will be designed and constructed to ensure long-term protection of the groundwater. Disposal facility construction will meet or exceed the equivalent performance standard for permeability identified in this requirement.

- Regulation 10 CSR 25-7.264(2)(N)1.A(IV)(e) provides siting criteria for hazardous waste landfills which restrict locating new facilities in an area subject to catastrophic collapse. This requirement is intended to ensure long-term protection of the disposal facility.

Cover

Requirements are specific in the various laws for disposal facility covers. The optimal cover, on the basis of the wastes to be disposed of, is a hybrid cover that consists of the major features of a RCRA cover plus the features of an UMTRCA cover aimed at long-term control of radon. The UMTRCA requirements in 40 CFR Part 192, Subparts A and D limit releases of Rn-222 to no more than 20 pCi/m^2-s and also specify that the cover (as well as the cell) be effective for 1,000 years to the extent reasonably achievable, and in any case, for at least 200 years. These requirements are applicable as they address by-product waste as defined in the regulations. The RCRA design requirements in 40 CFR 264.310(a) are relevant and appropriate because they address similar actions. 40 CFR 264.310(a) requires the cover to be designed to provide long-term minimization of migration of liquids, function with minimum maintenance, promote drainage and minimize erosion or abrasion of the cover, accommodate settling and subsidence so that the cover's integrity is maintained, and have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

Liner/Leachate Collection System

Design standards for liners and leachate collection systems are specified in the Missouri Code of State Regulations, TSCA and RCRA; no UMTRCA regulations apply. Missouri liner regulations require at least 2 ft of compacted soil with a hydraulic conductivity no greater than $1x10^{-6}$ cm/s. The RCRA specifies a double liner, double leachate collection system for hazardous waste landfills. The TSCA requirements, which are broader and take into consideration the nature of the waste and protectiveness of the overburden materials, require a liner consisting of 3 ft of compacted soil with a permeability equal to or less than $1x10^{-7}$ cm/s, or a synthetic membrane liner. The TSCA also provides for three different leachate collection systems:(1) simple leachate collection, (2) compound leachate collection, and (3) suction lysimeters.

Each of these three laws contains elements that should be considered relevant and appropriate; consequently, a hybrid system was selected on the basis of the following considerations: (1) all wastes to be disposed of are solid, nonhazardous wastes that are expected to generate only minimal leachate; (2) the site is underlain by thick, unsaturated, low-permeability soils; and (3) it is prudent in the short term to remove precipitation, construction water, and transient drainage using a leachate collection system.

For these reasons, the RCRA requirements for a double liner and leachate collection system are considered relevant and appropriate and are presented below.

Liner

The liner must be: (1) constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure due to pressure gradients (including static head and external hydrogeologic forces), physical contact with the waste or leachate to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operations; (2) placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift; and (3) installed to cover all surrounding earth likely to be in contact with the waste or leachate.

The leachate collection and removal system (LCRS) immediately above the liner must be designed, constructed, maintained, and operated to collect and remove leachate from the cell so that leachate depth over the liner does not exceed 1 ft.

The LCRS must be constructed of materials that are: (1) chemically resistant to the expected waste and the leachate expected to be generated; and (2) of sufficient strength and thickness to prevent collapse under the pressure exerted by overlying wastes, waste cover materials, and by any equipment used at the disposal cell.

The liner system must include: (1) a top liner designed and constructed of materials (e.g., a geomembrane) that will prevent the migration of hazardous constituents into such liner during the active life and post-closure care period; and (2) a composite bottom liner, consisting of at least two components. The upper component must be designed and constructed of materials (e.g., a geomembrane) that will prevent the migration of hazardous constituents into this component during the active life and post-closure care period. The lower component must be designed and constructed of materials that will minimize the migration of hazardous constituents if a breach in the upper component were to occur. The lower component must be constructed of at least 3 ft of compacted soil material with a hydraulic conductivity of no more than 1×10^{-7} cm/sec.

The LCRS immediately above the top liner must be designed, constructed, operated, and maintained to collect and remove leachate from the cell during the active life and post-closure care period, and the leachate depth over the liner must not exceed 1 ft.

The LCRS between the liners, and immediately above the bottom composite liner is also a leak detection system (LDS). This LDS must be capable of detecting, collecting, and removing leaks of hazardous constituents at the earliest practicable time through all areas of the top liner likely to be exposed to waste or leachate during the active life and post-closure care period. The LDS must be: (1) constructed with a bottom slope of 1% or more; (2) constructed of granular drainage materials with a hydraulic conductivity of 1×10^{-2} cm/sec or more and a thickness of 12 in. or more; or constructed of synthetic or geonet drainage materials with a transmissivity of 3×10^{-5} m^2/sec or more; (3) constructed of materials that are chemically resistant to the waste materials in the cell and the leachate expected to be generated, and of sufficient strength and thickness to prevent collapse under the pressure exerted by overlying wastes, waste cover materials, and equipment used at the disposal cell; (4) designed and operated to minimize clogging during the active life and post-closure care period; and (5) constructed with sumps and liquid removal methods (e.g., pumps) of sufficient size to collect and remove liquids from the sump and prevent liquids from backing up into the drainage layer. Each unit must have its own sumps. The design of each sump and removal system must provide a method for measuring and recording the volume of liquids present in the sump and the liquids removed.

Liquids in the leak detection system sumps must be collected and removed to minimize the head on the bottom liner.

A run-on control system must be designed, constructed, operated, and maintained that is capable of preventing flow onto the active portion of the cell during peak discharge from at least a 25-year storm. In addition, a run-off management system must be designed, constructed, operated, and maintained to collect and control at least the water volume resulting from a 24-hour, 25-year storm.

Collection and holding facilities (e.g., basins) associated with run-on and runoff control systems must be emptied or otherwise managed expeditiously after storms to maintain the design capacity of the system.

Any waste with particulate matter that may be subject to wind dispersal must be covered or otherwise managed to control wind dispersal.

As a function of the LCRS, an action leakage rate (ALR) must be determined. The ALR is the maximum design flow rate that the leak detection system can remove without the fluid head on the bottom liner exceeding 1 ft. The ALR must include an adequate safety margin to allow for uncertainties in the design (e.g., slope, hydraulic conductivity, thickness of drainage material), construction, operation, and location of the leak detection system (LDS), waste and leachate characteristics, likelihood and amounts of other sources of liquids in the LDS, and proposed response action (e.g., the ALR must consider decreases in the flow capacity of the system over time resulting from siltation and clogging, rib layover and creep of synthetic components of the system, overburden pressures, etc.).

To determine if the ALR has been exceeded, the weekly or monthly flow rate must be converted from the monitoring data to an average daily flow rate (gallons per acre per day) for each sump. The average daily flow rate for each sump must be calculated weekly during the active life and closure period, and monthly during the post-closure care period.

After the final cover is installed, the amount of liquids removed from each LDS sump must be recorded at least monthly. If the liquid level in the sump stays below the pump operating level (liquid level based on pump activation level, sump dimensions, and level that avoids backup into the drainage layer and minimizes head in the sump) for two consecutive quarters, the amount of liquids in the sumps is then recorded at least semiannually. If at any time during post-closure, the pump operating level is exceeded at units on quarterly or semiannual recording schedules, recording must be performed monthly until the liquid level again stays below the pump operating level for two consecutive months.

The action leakage rate for the disposal cell will be developed in agreement with the Missouri Department of Natural Resources.

During construction or installation, liners and cover systems (e.g., membranes, sheets, or coatings) must be inspected for uniformity, damage, and imperfections (e.g., holes, cracks, thin spots, or foreign materials). Immediately after construction or installation: (1) synthetic liners and covers must be inspected to ensure tight seams and joints and the absence of tears, punctures, or blisters; and (2) soil-based and admixed liners and covers must inspected for

imperfections including lenses, cracks, channels, root holes, or other structural nonuniformities that may cause an increase in the permeability of the liner or cover.

During operation, the disposal cell must be inspected weekly and after storms to detect evidence of: (1) deterioration, malfunctions, or improper operation of run-on and runoff control systems; (2) proper functioning of wind dispersal control systems, where present; and (3) the presence of leachate in and proper functioning of the leachate collection and removal system.

Waste Placement

The Land Disposal Restrictions (LDRs) set forth in 40 CFR 268 place specific restrictions (e.g., treatment of waste to concentration levels) on RCRA hazardous waste prior to placement in land disposal units. Certain activities carried out under the remedial action may constitute placement; for example, placing sludge or sediment into a sedimentation tank and then redepositing the material back into the source area, or the movement of waste from one area to another prior to treatment. WSSRAP characteristic hazardous wastes will be treated to the applicable specified treatment standards prior to placement in the disposal cell. Therefore, the LDRs for placement (or the transfer from on-site location to on-site location) of wastes have been waived in the ROD under the provisions of Section 121(d)(4)(A) of CERCLA. See also the Additional Treatment portion of Section 4.3.3.

RCRA 40 CFR 264.314(f) sets forth restrictions on the placement of waste containing free liquids in a landfill and is waived in the ROD only with respect to grout used in filling voids of dismantlement debris. It will be determined during pilot-scale testing that any free liquids generated during solidification process will pass the toxicity characteristic leaching procedure (TCLP) test. The free liquids will be randomly tested during full scale operations to ensure that they pass the TCLP test. Also, all grout-like material will achieve a minimum unconfined compressive strength (UCS) of 50 psi in place at 28 days as documented through bench and pilot scale testing. Placement methods (e.g., compaction) that minimize long-term subsidence of the cell cover will be used for non-grout materials.

The National Emission Standards for Hazardous Air Pollutants (NESHAPS) requirements for Rn-222 emissions from the disposal of uranium mill tailings are given in

40 CFR 61 Subpart T. According to this standard, Rn-222 emissions to the ambient air shall not exceed 20 pCi/m^2-s. This requirement is relevant and appropriate for final site conditions.

Subpart Q sets forth the standard for radon emissions. The standard states that no source at a DOE facility shall emit more than 20 pCi/m^2s of Rn-222 into the air as an average for the entire source. This standard is applicable at completion of the final remedial action because the Weldon Spring site is a DOE facility.

Regulation 40 CFR 61 Subpart H regulates emissions of radionuclides other than radon from DOE facilities. Emissions of these radionuclides to the ambient air shall not exceed amounts that would cause any member of the public to receive an effective dose equivalent of 10 mrem per year.

Missouri radiation regulations in 19 CSR 20-10.040(4) specify a quarterly Rn-222 limit of $1x10^{-9}$ μC/ml (1 pCi/l) above background in uncontrolled areas. It is possible that site activities might result in temporary exceedances of the standard during the cleanup period. Because compliance with the requirement during remedial implementation is technically impracticable, this standard is waived under the provisions of Section 121(d)(4)(C) of CERCLA during implementation.

Regulation 19 CSR 20-10.090(1) is applicable as it regulates the disposal of radioactive wastes such that no radioactive material shall be released into the air or water in a manner which causes exposure of any person above the limits specified in 19 CSR 20-10.040. This State regulation establishes maximum permissible exposure limits for both external and internal exposure for persons within or outside controlled areas. The exposure limits are specified in Table I and Appendix I Table 2 of 19 CSR 20-10.040.

Several State air quality standards are applicable to the implementation phase of the remedial action. State regulation 10 CSR 10-5.180 provides particulate standards for internal combustion engines. This regulation states that there will be no visible emission of air contaminants from any internal combustion engine for more that ten consecutive seconds at any one time. State regulation 10 CSR 10-6.170 provides restrictions of particulate matter to the ambient air such that the particulate matter may not go beyond the premises of origin in quantities that remain visible in the ambient air or may be found on surfaces beyond the property line of origin. Oil may not be used for dust suppression (10 CSR 25-11.010).

4.2.3.3 **Treatment and Processing.** The hazardous waste treatment requirements specified in 40 CFR 264 and 10 CSR 25-7.264 are applicable. These include general facility standards, preparedness and prevention standards, and standards for closure upon completion of the remedial action. All treated material must pass the TCLP test prior to placement, which will ensure adequate treatment. In addition, the requirements in 40 CFR 264, Subpart X, *Miscellaneous Units*, are also applicable. These requirements state that a miscellaneous unit must be located, designed, constructed, operated, maintained, and closed in a manner that will ensure protection of human health and the environment. Protection measures include prevention of any releases due to migration of waste constituents in groundwater or the subsurface environment, surface water, wetlands, soil surface, or air.

Size Reduction (Section 5.3.4), Dewatering (Section 5.3.5), and Decontamination (Section 5.3.6) are certain aspects of the various treatment processes. A discussion of the regulatory concerns for each are found in the respective segments of Section 5.

Regulation 10 CSR 10-6.170 provides restrictions of particulate matter to the ambient air such that the particulate matter may not go beyond the premises of origin in quantities that remain visible in the ambient air or may be found on surfaces beyond the property line of origin. This requirement is applicable to any treatment process that may emit particulate matter.

Chemical Stabilization/Solidification

RCRA 40 CFR 264.314(f) restricts placement of wastes containing free liquids in a landfill. To compensate for the free liquids in the grout that allows the grout to flow into voids of dismantlement debris, grout placement techniques can be developed and specified so that free liquids are effectively removed by the leachate collection system. Grout placement techniques could include thin lifts of grouted debris, which will promote drainage of liquids, and temporary sumps for collection and removal of liquids from the cell. A determination will be made during pilot-scale testing to ensure that any free liquids generated during the solidification process will pass the TCLP test. The free liquids will be randomly tested during full scale operations to ensure that they pass the TCLP test. Also, all grout-like material will achieve a minimum UCS of 50 psi in place at 28 days as documented through bench and pilot scale testing.

Other RCRA requirements that apply to the treatment process are the tanks requirements (40 CFR 264.192-194). These requirements are presented below.

Tanks

New tanks must be handled properly to prevent damage to the tanks during installation. Prior to placing a new tank in use, an independent, qualified installation inspector or an independent, qualified, registered professional engineer, either of whom is trained and experienced in the proper installation of tank systems or components, must inspect the tank for the presence of weld breaks, punctures, scrapes of protective coatings, cracks, and corrosion. All discrepancies must be remedied before the tank is placed in use.

All new tanks and ancillary equipment must be tested for tightness prior to use. If a tank is found not to be tight, all repairs necessary to remedy the leaks must be performed prior to placing the tank in use.

Ancillary equipment must be supported and protected against physical damage and excessive stress due to settlement, vibration, expansion, or contraction.

New tanks must be a secondary containment system which must be: (1) designed, installed, and operated to prevent any migration of wastes or accumulated liquid out of the system to the soil, groundwater, or surface water at any time during the use of the tank; and (2) capable of detecting and collecting releases and accumulated liquids until the collected material is removed.

The secondary containment system must be at a minimum: (1) constructed of or lined with materials that are compatible with the wastes to be placed in the tank system and must have sufficient strength and thickness to prevent failure owing to pressure gradients (including static head and external hydrological forces), physical contact with the waste to which it is exposed, climatic conditions, and the stress of daily operation (including stresses from nearby vehicular traffic); (2) placed on a foundation or base capable of providing support to the secondary containment system, resistance to pressure gradients above and below the system, and capable of preventing failure due to settlement, compression, or uplift; (3) provided with a leak-detection system that is designed and operated so that it will detect the failure of either the primary or secndary containment structure or the presence of any release of hazardous waste or accumulated liquid in the secondary containment system within 24 hours; and (4) sloped or otherwise designed or operated to drain and remove liquids resulting from leaks, spills, or precipitation.

Spilled or leaked waste and accumulated precipitation must be removed from the secondary containment system within 24 hours.

Secondary containment for tanks must include one or more of the following devices: a liner (external to the tank), a vault, or a double-walled tank.

External liner systems must be: (1) designed or operated to contain 100% of the capacity of the largest tank within its boundary; (2) designed or operated to prevent run-on or infiltration of precipitation into the secondary containment system unless the collection system has sufficient excess capacity to contain run-on or infiltration. Such additional capacity must be sufficient to contain precipitation from a 25-year, 24-hour rainfall event; (3) free of cracks or gaps; and (4) designed and installed to surround the tank completely and to cover all surrounding earth likely to come into contact with the waste if the waste is released from the tanks (i.e., capable of preventing lateral as well as vertical migration of the waste).

Hazardous wastes or treatment reagents must not be placed in a tank system if they could cause the tank, its ancillary equipment, or the containment system to rupture, leak, corrode, or otherwise fail.

Appropriate controls and practices must be used to prevent spills and overflows from the tank or containment system. These include at a minimum: (1) spill prevention controls (e.g., check valves, dry disconnect couplings); (2) overfill prevention controls (e.g., level sensing devices, high level alarms, automatic feed cutoff, or bypass to a standby tank); and (3) maintenance of sufficient freeboard in uncovered tanks to prevent overtopping by wave or wind action or by precipitation.

Federal regulation 40 CFR 61 Subpart H regulates emissions of radionuclides other than radon from DOE facilities. Emissions of these radionuclides to the ambient air shall not exceed amounts that would cause any member of the public to receive an effective dose equivalent of 10 mrem/year. In addition, 10 CSR 10-6.170 provides restrictions of particulate matter to the ambient air such that the particulate matter may not go beyond the premises of origin in quantities that remain visible in the ambient air or may be found on surfaces beyond the property line of origin.

OSHA regulations specified in 29 CFR 1910.120, *Hazardous Waste Operations and Emergency Response*, set forth requirements for implementing safety and health programs; hazardous communications programs; training; medical surveillance; materials handling and emergency response programs for treatment, storage, or disposal (TSD) facilities. The operation of the chemical stabilization/solidification (CSS) facility will incorporate these administrative requirements.

Vitrification

Federal regulation 40 CFR 266, Subpart H sets forth RCRA emission standards for hazardous waste burned in industrial furnaces and boilers. The standard specifies a destruction and removal efficiency (DRE) of 99.99% for each principal organic hazardous constituent. The standard also gives limits on the emissions of carbon monoxide (CO) in the off-gas, and particulate emissions.

TSCA at 40 CFR 761 contains requirements for the incineration of polychlorinated biphenyls (PCBs). The requirements include off-gas retention times, combustion efficiency rates of 99.9% and DREs of 99.9999%.

The NESHAP standards in 40 CFR 61 Subpart N govern requirements for arsenic emissions from glass manufacturing plants. This standard is considered relevant and appropriate for the vitrification alternative, because the vitrification unit would be considered sufficiently similar to a regulated process.

Federal regulation 40 CFR 61 Subpart H regulates emissions of radionuclides other than radon from DOE facilities. Emissions of these radionuclides to the ambient air shall not exceed amounts that would cause any member of the public to receive an effective dose equivalent of 10 mrem/year.

The emission standard for radon discussed in 40 CFR 61 Subpart Q is appropriate for all remediation activities at the site, as it relates specifically to Department of Energy facilities. Federal regulation 40 CFR 61.192 states that no source at a Department of Energy facility shall emit more than 20 pCi/m^2-s into the air.

The State of Missouri has adopted the NAQS criteria specified in the *Clean Air Act* through the *State Implementation Plan* and has promulgated ambient concentration standards under 10 CSR 10.6.010. Implementation of the vitrification alternative could result in emissions of several of the criteria pollutants, including particulate matter. Ambient standards for these contaminants are not ARARs; however, the standards provide a sound technical basis for ensuring protection of public health and welfare during implementation and will be considered for those actions involving potential air releases.

The Missouri Air Regulations at 10 CSR 10-6.060 specify de minimis levels of various pollutants that cannot be exceeded without a permit. Although a permit is not required for an on-site CERCLA action, the vitrification alternative would comply with the substantive requirements as relevant and appropriate criteria.

Missouri Radiation Regulations at 19 CSR 20-10.040(4) specify a quarterly Rn-222 limit of 1×10^{-9} μC/ml (1 pCi/l) above background in uncontrolled areas. It is possible that a few site activities, i.e., vitrification might result in temporary exceedances of the standard, which is allowable based on the waiver in the ROD.

State regulation 10 CSR-5.030 places restrictions on emissions of particulate matter from fuel burning equipment used for indirect heating. While such equipment would be used for direct heating of wastes in the vitrification system, this requirement would be relevant and appropriate based upon similarity of conditions.

State regulation 10 CSR 10-5.050 limits particulate matter from industrial sources. State regulation 10 CSR 10-5.090 limits the opacity of exit gases.

State regulation 19 CSR 20-10.090(1) regulates the disposal of radioactive wastes such that no radioactive material shall be released into the air or water in a manner which causes exposure of any person above the limits specified in 19 CSR 20-10.040. This State regulation establishes maximum permissible exposure limits for both external and internal exposure for persons within or outside controlled areas. The exposure limits are specified in Table I and Appendix I Table 2 of 19 CSR 20-10.040.

The vitrification alternative will be implemented under DOE Order 5400.5, *Radiation Protection of the Environment* Chapter II, "Requirements for Radiation Protection of the Public

and the Environment," and Chapter III, "Derived Concentration Guides for Air and Water;" and DOE Order 5484.1, *Environmental Protection, Safety, and Health Protection Information Reporting Requirements*. DOE Order 5400.5 Chapter II sets forth public dose limits, the ALARA process, and guidelines for management of low level radioactive waste. Chapter III provides DCG reference values for ingestion of water, inhalation of air,and immersion in a gaseous cloud. DOE Order 5484.1 limits in-stack radon concentrations. This order also establishes requirements and procedures for the investigation of occurrences having environmental protection significance. Investigations are defined as Type A (fatal injury); Type B (release of radioactive materials); and Type C (occupational injuries and illnesses).

Federal regulation 40 CFR 266 Subpart H also sets forth operating and monitoring requirements for industrial furnaces burning hazardous wastes. Operating requirements specify operating the melter with an automated feed cutoff system, and controlling fugitive emissions from the combustion zone by keeping the zone totally sealed or maintaining the zone at a pressure lower than atmospheric.

Monitoring requirements include continuous monitoring of combustion temperature, waste feed rate and combustion gas velocity; carbon monoxide, oxygen and total hydrocarbons. This monitoring must be done in compliance with performance specifications in Appendix IX of 40 CFR 266.

In addition, there are daily inspection requirements for leaks, spills, fugitive emissions and signs of tampering with the melter and associated equipment. The emergency waste feed cutoff system must be tested weekly.

OSHA regulations specified in 29 CFR 1910.120, *Hazardous Waste Operations and Emergency Response*, set forth requirements for implementing safety and health programs; hazardous communications programs; training; medical surveillance; materials handling and emergency response programs for TSD facilities. The operation of the vitrification facility will incorporate these administrative requirements.

Additional Treatments

There are five groups of waste not addressed under CSS or Vitrification. These groups are:

- Solid and liquid RCRA hazardous wastes stored in Building 434.
- PCB-contaminated soils, sludges, liquids and containers stored in Building 434.
- Cooling tower wood preserved with chromated copper arsenate salts.
- Water treatment plant sludges.
- TPB liquids contaminated with mercury and PCBs stored in Building 434.

LDRs found in 40 CFR 268 specify treatment standards which must be attained before LDR wastes or treatment residuals may be land disposed (i.e., placed in the disposal cell). LDR wastes fall into one of two categories, those wastes subject to concentration-based treatment standards and those wastes subject to specific technology treatment standards. Compliance with a concentration-based treatment standard requires only that the treatment level be achieved. Once achieved, the waste may be land disposed. Most of the LDR wastes generated and stored at the site are subject to concentration-based treatment standards. These standards will be attained prior to land disposal.

The second type of treatment standard is based on the use of a specified technology. In these circumstances, a specific technology is required for the wastes, and, as long as the wastes are treated by this technology, the treatment residuals are assumed to meet the treatment standards. Technologies other than the specified technologies may be used to treat wastes subject to this type of treatment standard; however, it must be demonstrated that the alternative treatment method can achieve a measure of performance equivalent to that achievable by the specified technology. A limited amount of LDR wastes at the site are subject to specified technology treatment standards. Given the limited national capacity for managing mixed waste, the specified technology may not be available. These types of wastes and the specified treatment technologies are listed below. If it is determined that the applicable specified technology is not available for the LDR waste the alternative treatment method listed below shall be implemented. In this case, the LDR treatment standard is waived under the provisions of Section 121(d)(4)D) of CERCLA. The effectiveness of these alternative technologies will be demonstrated by TCLP assurance testing prior to disposal.

1. Type of Waste: D001-High TOC Non-wastewater.
   Specified Technology: Incineration, fuel substitution, or recovery.
   Alternative Technology: Oxidation.

2. Type of Waste: California List-Liquid hazardous wastes containing greater than or equal to 50 ppm PCBs.
   Specified Technology: Incineration in accordance with 40 CFR 761.70 or burned in a high efficiency boiler in accordance with 40 CFR 761.60.
   Alternate Technology: Oxidation followed by stabilization.

3. Type of Waste: D008-Lead batteries.
   Specified Technology: Thermal recovery in a lead smelter.
   Alternate Technology: Stabilization.

4. Type of Waste:. D008-Radioactive lead solids.
   Specified Technology: Macroencapsulation.
   Alternative Technology: Stabilization.

5. Type of Waste: D009-Elemental Mercury Contaminated with Radioactive Materials.
   Specified Technology: Amalgamation.
   Alternative Technology: Amalgamation followed by stabilization.

It should be noted that the best demonstrated available technology (BDAT) for D008-nonwastewater wastes, which are subject to a concentration-based treatment standard, is stabilization.

Treatment standards for RCRA solid waste can generally be achieved with existing or proposed on-site treatment systems. On-site vitrification would achieve the treatment standard for PCB waste (99.9999% DRE). The CSS process would allow treatment standards for arsenic contaminated wood to be achieved. While no characterization of water treatment plant sludges have been done to date, the heavy metals are expected to be able to be treated by either CSS or vitrification. A detailed discussion on all of the proceeding treatment technologies is found in Section 5.9.7.2, Summary of Additional Treatments.

4.2.3.4 Site Closure. Regulation 40 CFR 264 Subpart G contains the RCRA closure performance standards. Other closure standards must also be followed for the various structures existing or constructed for the remediation, such as surface impoundments, waste piles, containers, tanks, and landfills. These standards are listed in Subparts K, L, I, J, and N, respectively. Part 264.111 states that the facility must be closed in such a manner as to control,

minimize or eliminate post-closure escape of hazardous waste, leachate, contaminated runoff or hazardous waste decomposition products to the ground and surface waters or to the atmosphere. Part 264.117 specifies that post-closure care must continue for 30 years after closure. Other pertinent sections include 40 CFR 264.178 related to closure requirements for tank systems; 40 CFR 264.228, closure of surface impoundments; 40 CFR 258, closure of waste piles; and 40 CFR 264.310, closure of landfills. The post-closure care period includes maintenance of the cover, the leachate collection system and the groundwater monitoring system. Subpart G also specifies that post-closure use of the property must not be allowed to disturb the integrity of the final cover, liners, or any other component of the containment system, or function of the monitoring system.

The UMTRCA standards in 40 CFR 192 Subpart D specify that the control of radiological hazards be effective for 1,000 years, to the extent reasonably achievable, and, in any case, at least 200 years; and also that closure practices limit releases of Rn-222 so as not to exceed an average release rate of 20 pCi/m^2-s. These standards for the management of uranium by-product material address releases of radon from disposal areas after the closure period. These radon flux standards are applicable after the bulk waste has been placed in the cell and the final cell cover completed. The NESHAP regulations 40 CFR 61 Subpart Q and T also contain the radon limit of 20 pCi/m^2-s and must be met at completion of the disposal cell.

The UMTRCA standards in 40 CFR 192 Subpart A relate to control of residual radioactive material from inactive uranium processing sites. While these standards are not applicable to the Weldon Spring site, they are considered relevant and appropriate as the materials regulated are similar in nature. 40 CFR 192.02(b)(1) contains the 20 pCi/m^2-s radon flux standard as discussed above for Subpart D. In addition, 40 CFR 192.02(b)(2) limits any increase in the annual average concentration of radon-222 in the air at or above any location outside the disposal site by more than 0.5 pCi/l.

UMTRCA standards in 40 CFR 192, Subpart B address residual concentration levels of Ra-226 in soil. Residual levels should not exceed background by more than 5 pCi/g in the top 15 cm of soil or 15 pCi/g in each 15 cm layer below the top layer, averaged over an area of 100 m^2. This standard is relevant and appropriate to final site conditions and is calculated in the soil clean-up criteria.

4.2.3.5 Long-Term Monitoring and Maintenance. Requirements for post-closure monitoring and maintenance are specified in the RCRA and UMTRCA. The TSCA does not define specific post-closure requirements for a chemical waste landfill. Requirements under RCRA specify a 30-year post-closure care period of maintenance of the cover, the leachate collection system, and the groundwater monitoring system. Post-closure standards under UMTRCA require the control of radiological hazards to (1) be effective for 1,000 years, to the extent reasonably achievable, and in any case, at least 200 years; and (2) limit releases of Rn-222 so as not to exceed an average release rate of 20 pCi/m^2-s.

These UMTRCA standards are relevant and appropriate because they address similar waste materials and a disposal scenario similar to the WSSRAP. The UMTRCA requirements also directly reference the RCRA requirements of 40 CFR 264.111 with respect to the closure performance standard for nonradiological hazards. Therefore, 40 CFR 264.111 and 264.310 are also relevant and appropriate. Since the hazardous waste monitoring/maintenance requirements are more stringent than the solid waste requirements, the latter are not considered as ARARs. The RCRA requirements for post-closure care of landfills (40 CFR 264.310(b)) require the owner/operator to (1) maintain the integrity and effectiveness of the final cover, including making repairs to the cap as necessary to correct the effects of settling, subsidence, erosion, or other events; (2) continue to operate the leachate collection and removal system until leachate is no longer detected; (3) maintain and monitor the groundwater monitoring system; (4) prevent run-on and runoff from eroding or otherwise damaging the final cover; and (5) protect and maintain surveyed benchmarks. 40 CFR 264 Subpart F and especially 264.97, *General Groundwater Monitoring Requirements*, is also relevant and appropriate because this section discusses general groundwater protection standards, sampling, detection, monitoring, and corrective action. In addition, State regulation 10 CSR 25-7.264(2)(f) sets forth surface water monitoring requirements to detect impacts from groundwater contamination. This monitoring should be conducted through the post-closure care period.

4.3 Environmental Safety and Health Issues

Environmental safety and health issues for the site remedial action include the health and safety of site workers, and protection of the environment and the public. To ensure that the activities involved in this project do not result in any adverse effects to these areas of concern, the WSSRAP has developed and implemented programs and procedures to maintain and control potential exposures or releases within acceptable standards established by the U.S. Department

of Energy, the Occupational Safety and Health Administration, the Environmental Protection Agency, and other applicable standards and recommendations. The following subsections (listed below) describe the various components used to evaluate and control contaminants found at both the chemical plant site and the quarry site:

- Contaminant concentrations (sources)
- Worker exposure limits
- Construction safety
- Personal protective equipment requirements
- Engineering controls
- Contamination controls
- Monitoring requirements
- Contingency plans

4.3.1 Contaminant Concentrations In Source Areas

Currently, the chemical plant and raffinate pit areas include contaminated soils and sludge which contain chemical and radioactive constituents. Sources of contamination included in the chemical plant and raffinate pit areas are: four raffinate pits, Ash Pond, Frog Pond, north dump, south dump, the coal storage area, and soils near former processing facilities.

Chemical analyses of the soils showed that concentrations greater than background exist for all of the metals and anions included in the analyses. The metals and anions occurring with the greatest frequency above the background range include silver, arsenic, cadmium fluoride, mercury, nickel, nitrate, lead, antimony, sulfate, and zinc. Low levels of nitroaromatic compounds were detected, particularly in the area of Ash Pond. Low concentrations of volatile organic compounds, pesticides, polychlorinated biphenyls (PCBs) in soils were detected in limited areas. Low concentrations of semivolatile organic compounds are present in areas related to burning and coal storage.

The radiological sampling of soils across the site showed widespread surface contamination of uranium with a lesser extent of contamination of radium and thorium. Varying depths of soil with radionuclide concentrations in excess of reference levels are present in Ash Pond, Frog Pond, the south dump, and the north dump. Radionuclide concentrations above

reference levels scattered throughout the soils in the other site areas are mostly within the top 1 ft.

Radiological analysis of the raffinate pits showed that the sludge contained several hundred to several thousand pCi/g of uranium, radium, and thorium isotopes. The ranges of isotopes in Raffinate Pits 1, 2, and 3 are similar, reflecting sludge from similar process operations. Raffinate Pit 4 contains the same type of neutralized raffinate solids as Raffinate Pits 1, 2, and 3, with the addition of waste from processing thorium and drums and rubble from the shutdown of the uranium feed materials plant.

Chemical analysis of the sludge in the raffinate pits showed some homogeneity among all of the pits except Raffinate Pit 4. The sludge contains high concentrations greater than background for all metals and anions included in the analysis. Low concentrations of the heavy metals are maintained in the raffinate pits water. Uranium, vanadium, and molybdenum, which exist as cationic species at the pH and redox potential conditions of the raffinate material, are quite soluble in the raffinate pit water and are available for migration through the subsurface.

In addition to the chemicals and radiological contaminants, various drums containing materials from the chemical plant and process equipment are located in Raffinate Pit 4. Asbestos contaminated materials are also contained in substances disposed of at Raffinate Pit 4.

The buildings and associated materials and equipment contain radioactive process chemicals, asbestos, and PCBs. Sampling of the buildings for asbestos revealed the presence of asbestos-containing material in the insulation on pipes, steam valves, heating ducts, and in corrugated siding. Radiological sampling of the interior and exterior of the buildings, equipment within the building, and air showed that roughly half of the buildings meet the standards for release for unrestricted used. Ninety-one percent of the air samples were below the occupations standards for radiological exposure.

At the quarry site, it is estimated that approximately 95,000 cu yd of contaminated waste materials consisting of structural debris, drummed and unconfined wastes, process equipment, sludge, and other solid materials have been deposited. Uranium, thorium, radium, and radon are the radioactive constituents of concern. Chemical contaminants are known to include nitroaromatic compounds, polynuclear aromatic hydrocarbons (PAHs), PCBs, and heavy metals. Representative sampling of the in-place material is complicated by the heterogeneity of the

waste. The quarry pond, containing approximately 3 million gallons of contaminated water, shows elevated levels of uranium manganese, arsenic, and 2,4-dinitrotoluene. Groundwater in the limestone bedrock of the quarry contains elevated concentrations of uranium, thorium, nitroaromatic compounds, nitrate, sulfate, and chlorides.

More in depth information for either the chemical plant site or the quarry site can be obtained from the *Remedial Investigation for the Chemical Plant Site* (Ref. 4) and *Remedial Investigation for Quarry Bulk Wastes* (Ref. 28). Tables 4.3-1, 4.3-2, and 4.3-3 are reproduced from the above reports to summarize the contaminants that may be handled during the preparation of the site.

4.3.2 Worker Exposure Limits

Worker exposures at the site can be categorized into two general categories: exposures to radiological contaminants and exposure to hazardous materials. As such, the WSSRAP has established exposure guidelines as required by DOE Orders 5480.04, 5480.10, and 5480.11 which are consistent with current DOE, OSHA and American Conference of Governmental Industrial Hygienists (ACGIH) standards. The OSHA has set forth exposure limits in 29 CFR 1910.1000 and 29 CFR 1926 that will be applicable to the WSSRAP. In addition, where Federal standards have not been developed or adopted, the latest ACGIH Threshold Limit Values and Biological Exposure Indices or other appropriate professional organization exposure guidelines may be used.

Worker radiation exposures are maintained within the dose limits set forth in the *WSSRAP Radiological Control Manual* (Ref. 37). In addition to meeting the DOE requirement for radiological exposure, a lower administrative dose limit of 500 mrem per year total effective dose equivalent has been established in the *WSSRAP Radiological Control Manual*. Although the administrative dose limits and the limits found in the summary in the table below are established dose limits, the process of reducing radiation exposures ALARA is a fundamental requirement of the WSSRAP radiological control program. In addition to radiological exposure control, hazardous chemicals including confirmed human carcinogens and suspect carcinogens are included in the ALARA program.

Type of Exposure	Annual Limit
Radiological worker: whole body (internal + external).	5 rem
Radiological worker: lens of eye.	15 rem
Radiological worker: extremity (hands and arms below the elbow; feet and legs below the knees).	50 rem
Radiological worker: any organ or tissue (other than lens of eye) and skin.	50 rem
Declared pregnant worker: embryo/fetus.	0.5 rem in 9 months
Minors and students (under age 18): whole body (internal + external).	0.1 rem
Visitors* and public: whole body (internal + external).	0.1 rem

* Applies to visitors who have not completed training in accordance with Articles 632 and 633 or have not met the special considerations of Article 667 of the *U.S. Department of Energy Radiological Control Manual* (Ref. 41).

4.3.3 Construction Safety

All work performed during this project will be performed in a safe and orderly manner so as not to create a hazard to health and property. Potential hazards associated with site remediation include various construction safety hazard. Due to the broad scope of work that will be involved in the remediation activities, a few of the typical safety hazards expected during this project include motor vehicle and heavy equipment operation, lifting and rigging, trenching, and excavation.

The subcontractors are responsible for developing and complying with a Safe Work Plan. The Safe Work Plan incorporates applicable provisions of the job specific Health and Safety Plan, applicable OSHA requirements, and any special safety and health measures the subcontractor intends to implement. All Safe Work Plans will be reviewed and approved prior to the commencement of work activities. The Safe Work Plans are then used as a guide to evaluate the performance of the subcontractors field activities on a daily basis.

4.3.4 Personal Protective Equipment Requirements

Personal protective equipment (PPE) policies and requirements are established by the WSSRAP in accordance with applicable standards, regulations, and good radiation protection; industrial hygiene; and construction safety practices. Site posting requirements exist to assist in identifying the hazardous materials, and/or radiological health and safety hazards in a given work area.

At the WSSRAP, minimum PPE requirements exist for simple entry into controlled areas and designated work areas outside of the controlled areas. They include safety glasses with side shields (meeting ANSI Z.87 specifications), hard hats (meeting ANSI Z.89), sturdy work shoes or boots, long pants, and shirts with sleeves.

PPE requirements for specific tasks or work activities other than simple entry are determined on a task specific basis. These additional requirements appear in the job specific Health and Safety Plan. Possible upgrades for the activities within the scope of this project may include use of full face air purifying respirators, cotton coveralls, chemical resistant boots, cotton gloves with surgical liner gloves.

Any PPE upgrade requirements are determined by the Environmental, Safety, and Health Department and the Safety Department. Once the technical approach has been determined, PPE requirements for specific tasks within the scope of work will be more adequately identified.

4.3.5 Engineering Controls

Engineering controls are utilized and designed to reduce potential exposures to personnel working at the WSSRAP, the environment, and the public. Engineering controls are the preferred technique for reducing and managing contaminants at their source. Personal protective equipment is utilized where engineering controls are inadequate, while installing engineering controls, or when engineering controls are impractical.

Due to the possibility of both radiological and chemical contamination that could be found in the soils, stringent dust control measures are required. Water spraying equipment will be used to suppress dust emissions to the lowest practical level. Excessive visible emissions of dust, smoke, or other particulate matter is unacceptable and steps will be required to reduce them. Airborne dust concentrations will not be permitted to exceed a limit of 1 mg/m^3. Other engineering controls may include the use of localized ventilation to capture emissions at the source, equipment modifications, or work practices to lower the potential for emissions.

4.3.6 Contamination Controls

The objective of the remediation at the WSSRAP is to treat and dispose of the contaminated waste found at the chemical plant site and the quarry. The main purpose of

contamination control during remediation is to ensure that contaminants are not spread from contaminated areas into uncontaminated areas or from areas of high contamination to areas of low contamination. Several contamination control measures are used at the WSSRAP to prevent the migration of contaminants off site.

Erosion control measures are included in specifications for all WSSRAP projects involving the disturbance of soil. These measures minimize erosion and off-site transport of soil and contamination. The WSSRAP PMC will monitor and assess projects for adequacy of erosion controls.

In addition, general site controls have been established for protection against inadvertent entrance of personnel into contaminated areas. Within the controlled areas there are restricted and unrestricted areas. In general, controlled areas in which radioactive, chemical, or asbestos contamination is present above established guidelines are "Restricted Areas". Restricted Area signs have been posted indicating the nature of the contamination present in each of these areas. Controlled areas in which site characterization data has indicated that no significant chemical and radiological hazard is present, are termed "unrestricted areas".

The WSSRAP controls access to the work site at all times. Workers are issued thermoluminescent monitoring badges (TLDs) daily at the access control point prior to entering the controlled area. Workers are also required to sign the controlled access area register indicating their work area before entering the controlled areas. Upon leaving the controlled area, they sign out on the same register. The wearing of personal protective equipment outside the controlled access area is not permitted. The WSSRAP requires personnel to radiologically "frisk" all garments worn under workers' PPE before removing the garments from the controlled access area.

The following measures apply to equipment that has become contaminated and requires cleaning. All vehicles, heavy equipment, tools and equipment being removed from the work areas are free of gross debris, dirt, and mud. Equipment and tools within the confines of the work zones require cleaning and a cursory scanning for radiological contamination before they are removed from the work zones.

4.3.7 Monitoring Requirements

The remedial action consists of treatment and disposal of wastes stored from the dismantling of an inactive uranium production facility, raffinate pits, a chemical plant, an abandoned limestone quarry, and associated vicinity properties. A variety of radiological, chemical, and asbestos contaminants can be contained in these wastes.

In addition to the contaminants contained in the wastes, other environmental and workplace hazards exist that could be introduced during the course of remediating the site. They may include hazardous materials brought on site by the subcontractor to perform a specific process (stabilization of the materials through chemical/stabilization solidification, vitrification, or other on-site treatment methods), or physical hazards produced by performing work, such as noise and heat and cold stress.

To assess and monitor the potential exposure of site personnel, the environment, and the public, extensive personal and area air monitoring will be performed to characterize and control any exposures to the variety of contaminants and physical hazards that may occur during the course of the project.

The WSSRAP has established monitoring and exposure guidelines as required by DOE Orders 5480.04, 5480.10, and 5480.11 that are consistent current DOE, OSHA and ACGIH standards.

Project specific monitoring requirements and responsibilities are specified in the job specific Health and Safety Plans. Any additional monitoring that may effect the environment is performed in accordance with the *Environmental Monitoring Plan for Calendar Year 1993* (Ref. 38).

4.3.8 Contingency Plans

Incidents that may occur during work at the WSSRAP include personal injuries, heat or cold stress, severe weather, and fires. All work at the WSSRAP is performed in crews of at least two persons (the "buddy system"). In the event of an emergency, emergency response personnel will be notified immediately by the use of two-way radio communication, which is available at all times to personnel in the field. Instruction in the emergency notification and

response procedures and the capabilities and limitations of on-site resources is provided to all personnel as part of the site orientation before field work begins.

The WSSRAP ensures that appropriate equipment and services are available to respond promptly to emergency events involving personal injury or other emergency situations.

An inventory list of equipment required for emergency response by subcontractors is supplied by the WSSRAP. All subcontractors maintain these items in the immediate work area. In the event of an accident involving personal injury, first aid is administered by the appropriate subcontractor supervisor or his designee with backup assistance from the WSSRAP PMC. Arrangements have been made with local ambulance services and fire protection districts to provide service to the Weldon Spring site. The capability to make emergency calls to the fire and ambulance services is maintained at all times.

The WSSRAP PMC is responsible for notifying all subcontractors in the event of tornado or severe thunderstorm warnings, or the threat of other severe weather conditions. Subcontractors are required to immediately perform those tasks necessary to stabilize the work site and proceed to the designated emergency shelter.

If any unusual materials or substances are uncovered during operations, work is halted in the affected work area and the WSSRAP PMC is notified immediately. Any such incident is evaluated by the WSSRAP PMC to determine whether additional personal protective equipment or other protective measures are required.

4.4 Quality Assurance

The *Project Management Contractor Quality Assurance Program* (QAP), (Ref. 6), will be implemented and adhered to during remedial action activities. The purpose of this program is to ensure that all work activities are performed in a quality manner and that all requirements including, but not limited to, DOE Orders, Federal, State, and local regulations, and corporate policies are satisfied. All remedial activities, including design activities, must be performed in such a manner that the required quality is attained or exceeded.

4.4.1 Quality Assurance Program

Quality assurance requirements for remedial action will comply and adhere with the approved WSSRAP Quality Assurance Program. The PMC is structured so that quality is achieved, acknowledged, and maintained. The organizational structure, levels of authority, and lines of communication for the remedial action will follow the established procedures.

A graded approach (a method that provides the application of management controls commensurate with criteria) will be utilized when applying quality assurance (QA) requirements to activities, processes, services, and items. The specific quality level assigned to an activity, process, service or item is based upon the level of control required in regard to the health and safety of the public and project personnel, the complexity of items, the consequences of failure, environmental impacts and cost, and the safe and reliable operation of the WSSRAP facility. A brief summary of the quality levels in the PMC QAP are as follows:

Quality Level 1: Items, processes, or services whose failure would: (a) cause an unacceptable safety or health impact or risk to employees or the public; (b) cause an unacceptable environmental impact or risk.

Quality Level 2: Items, processes, or services whose failure would degrade the performance or reliability of operations, data acquisition, or deliverables to an extent that would result in a significant risk of program interruption, dollar loss, or schedule delay, or whose failure would result in any environmental, health, or safety risk or hazards not currently and routinely accepted by the public.

Quality Level 3: Items, processes, or services whose failure would not result in any environmental, health, or safety risk not currently and routinely accepted by the public; nor would the failure pose significant program interruption, dollar loss, or schedule delay.

4.4.2 Personnel Training and Qualification

Personnel involved in the design and operations of the remedial activities will have the appropriate knowledge, skills, training and experience related to their area of responsibility.

4.4.3 Documents and Records

WSSRAP procedures control the preparation, review, approval, issuance, use, and revision of documents that prescribe work, specify requirements, establish design, or are otherwise pertinent to quality-related activities. These procedures also ensure that sufficient records are specified, prepared, reviewed, approved, and maintained to accurately reflect completed work.

Quality assurance records are completed documents that furnish evidence of the quality of items and/or quality-affecting activities. QA records provide documentary evidence that such activities are adequately controlled, and that associated parts, components, systems, facilities, and services comply with applicable requirements.

QA records will be maintained in a legible, identifiable, and retrievable manner and will be protected against damage and deterioration. Transmittal, distribution, and maintenance procedures governing them will be followed.

4.4.4 Design

All remedial design activities will be performed in accordance with approved engineering procedures. Design documents must be approved to support facility design, construction, turnover, start-up, and operation.

4.4.5 Procurement

All procurement activities for remedial action will comply with current WSSRAP procurement procedures and guidelines which require that suppliers of items or services have a quality assurance program consistent with DOE Order 5700.6C.

4.4.6 Inspection and Acceptance Testing

Inspection and testing activities related to remedial activities will be developed, controlled and documented. Inspection and acceptance testing of specified items and processes will be conducted using established acceptance and performance criteria.

Conformance of items and activities to specified requirements will be documented through inspections and surveillances. Test results will be evaluated by responsible authorities to ensure that test requirements have been satisfied.

4.4.7 Management Assessment

Management assessments are performed in accordance with approved procedures. Problems that, either potentially or in fact, could prevent or delay achieving WSSRAP mission objectives are identified, evaluated for resolution, tracked, and closed through preventive/ corrective measures. Feedback in the form of "lessons learned" are utilized whenever possible.

4.4.8 Environmental Quality Assurance Project Plan

The *Environmental Quality Assurance Project Plan* (EQAPjP) (Ref. 9) is intended to meet the applicable requirements of the U.S. Environmental Protection Agency's *Interim Guidelines and Specifications for the Preparation of Quality Assurance Project Plans* (Ref. 39). The EQAPjP addresses routine environmental monitoring, Remedial Investigation/Feasibility Studies (RI/FS) and other environmental aspects at the Weldon Spring site.

The Quality Assurance Program and the EQAPjP support quality affecting activities. The EQAPjP is supported by WSSRAP Standard Operating Procedures (SOPs), the WSSRAP Health and Safety Program, and work plans written for specific environmental tasks.

TABLE OF CONTENTS

NUMBER **PAGE**

5 SITE DESIGN DESCRIPTIONS 5-1

5.1 General 5-1

5.1.2 Waste Removal 5-2

5.1.2.1 General 5-2
5.1.2.2 Removal Plan 5-2

5.1.2.2.1 General 5-2
5.1.2.2.2 Functional Requirement 5-3
5.1.2.2.3 Performance Requirements 5-3
5.1.2.2.4 Alternatives Evaluated 5-3
5.1.2.2.5 Preferred Alternative 5-4
5.1.2.2.6 Technical Uncertainties 5-4
5.1.2.2.7 Contaminated Soils 5-4
5.1.2.2.8 Foundations and Underground Utilities 5-7
5.1.2.2.9 Temporary Storage Area Waste 5-9
5.1.2.2.10 Raffinate Pits 5-10
5.1.2.2.11 Material Staging Area Waste and Debris 5-14
5.1.2.2.12 Vicinity Properties 5-14
5.1.2.2.13 Water Treatment Plant Wastes 5-14
5.1.2.2.14 Waste from Other Areas 5-15
5.1.2.2.15 Removal Sequence and Schedule 5-15

5.1.2.3 Design Criteria and Specifications 5-19

5.1.3 Waste Handling and Transportation 5-21

5.1.3.1 General 5-21

TABLE OF CONTENTS (Continued)

NUMBER **PAGE**

5.1.3.2 Facilities 5-22
5.1.3.3 Handling and Transportation Plan 5-22

5.1.3.3.1 General 5-22
5.1.3.3.2 Functional Requirements 5-23
5.1.3.3.3 Performance Requirements 5-23
5.1.3.3.4 Evaluation of Alternatives 5-23
5.1.3.3.5 Preferred Alternative 5-24
5.1.3.3.6 Technical Uncertainties 5-24
5.1.3.3.7 Contaminated Soils 5-24
5.1.3.3.8 Concrete and Rubble 5-25
5.1.3.3.9 Raffinate Sludge 5-26
5.1.3.3.10 Other Wastes 5-26
5.1.3.3.11 Transportation Sequence and Schedule 5-26

5.1.3.4 Design Criteria and Specifications 5-27

5.1.4 Construction Materials Staging Area 5-28

5.1.4.1 General 5-28

5.1.4.1.1 Functional Requirements 5-28
5.1.4.1.2 Performance Requirements 5-28

5.1.4.2 Location and Layout of Storage Area 5-29

5.1.4.2.1 Off-Site Clay Borrow Storage 5-30
5.1.4.2.2 On-Site Clay Borrow Storage and Synthetic and Natural Materials Storage 5-32

TABLE OF CONTENTS (Continued)

NUMBER PAGE

5.1.4.3 Site Preparation 5-33
5.1.4.4 Surfacing 5-36
5.1.4.5 Surface Drainage Control 5-38
5.1.4.6 Design Criteria and Specifications 5-40

5.1.4.6.1 Level Areas and Equipment Access for Material Storage Piles 5-40
5.1.4.6.2 Access Roads 5-41
5.1.4.6.3 Staging Yard for Piping and Drainage Structures 5-41
5.1.4.6.4 Access Control Trailer 5-41
5.1.4.6.5 Equipment Tool Shed Area 5-41
5.1.4.6.6 Storm Water Run-on and Runoff Control 5-41
5.1.4.6.7 Fencing and Gates 5-42

5.1.4.7 CMSA System Analysis 5-42

5.1.5 Site Roads 5-43

5.1.5.1 General 5-43
5.1.5.2 Site Roadway System 5-45

5.1.5.2.1 Transportation Plan During Phase I Construction (CSS alternative) 5-49
5.1.5.2.2 Transportation Plan During Phase II Construction (CSS alternative) 5-50
5.1.5.2.3 Transportation Plan During Closure Phase Construction (CSS alternative) 5-51
5.1.5.2.4 Transportation Plan During Phase I & II Construction (VIT alternative) 5-51
5.1.5.2.5 Access to Vicinity Properties 5-51

TABLE OF CONTENTS (Continued)

NUMBER **PAGE**

5.1.5.2.6 Off-Site Borrow Haul Route 5-51
5.1.5.2.7 Site Roads Layout Design Criteria 5-56

5.1.5.3 Site Roadway Preparation 5-59
5.1.5.4 Surfacing 5-61
5.1.5.5 Summary of Design Criteria and Specifications 5-64
5.1.5.6 Site Roads System Analysis 5-65

5.1.6 Site Drainage 5-68

5.1.6.1 General 5-68
5.1.6.2 Functional Requirements 5-69
5.1.6.3 Performance Requirements 5-69
5.1.6.4 Storm Drainage Parameters 5-69
5.1.6.5 Existing Storm Drainage System 5-70
5.1.6.6 Storm Drainage System Modifications 5-71

5.1.6.6.1 Identification of Alternatives 5-71
5.1.6.6.2 Evaluation of Alternatives 5-72
5.1.6.6.3 Selection of Preferred Alternative 5-72
5.1.6.6.4 Details of Preferred Alternative 5-73
5.1.6.6.5 Technical Uncertainties 5-74
5.1.6.6.6 Alterations in Storm Drainage System During Disposal Facility Construction 5-74

5.1.6.7 Permanent Drainage Control Requirements 5-76

5.1.6.7.1 Functional Requirements 5-76
5.1.6.7.2 Performance Requirements 5-76

TABLE OF CONTENTS (Continued)

NUMBER **PAGE**

5.1.6.8 Design Criteria and Specifications 5-77
5.1.6.9 Site Drainage System Analysis 5-81

5.1.7 Borrow Materials 5-82

5.1.7.1 General 5-82

5.1.7.1.1 Functional Requirements 5-82
5.1.7.1.2 Performance Requirements 5-83
5.1.7.1.3 Identification and Evaluation of Alternatives . . 5-84

5.1.7.2 Materials Selection and Testing Criteria 5-85
5.1.7.3 Required Types of Borrow Materials 5-86
5.1.7.4 Location of Approved Sources 5-88

5.1.7.4.1 Low-Permeability (Fine-Grained) Material 5-88
5.1.7.4.2 Granular Materials 5-89
5.1.7.4.3 General Fill 5-90
5.1.7.4.4 Gravelly Topsoil and Rooting Medium Layers . 5-92

5.1.7.5 Design Criteria and Specifications 5-93

5.1.8 Other Facilities 5-94

5.1.8.1 General 5-94
5.1.8.2 Power Utilities 5-94
5.1.8.3 Water Distribution Utilities 5-95
5.1.8.4 Sewer and Storm Sewer Utilities 5-95
5.1.8.5 Laboratory Facilities 5-96
5.1.8.6 Leachate Storage and Treatment Facilities 5-98

TABLE OF CONTENTS (Continued)

NUMBER		PAGE
5.1.8.7	Covered Storage Facilities	5-100
5.1.8.7.1	RCRA and TSCA Regulated Materials	5-100
5.1.8.7.2	Asbestos-Containing Materials	5-100
5.1.8.7.3	Miscellaneous Items	5-101
5.1.8.8	Controlled Area Parking	5-101
5.1.8.9	Access Control	5-102
5.1.8.10	Contaminated Construction Equipment Maintenance Area	5-103
5.1.8.11	Dust Control Facilities	5-103
5.1.8.12	Pond Dewatering Facilities	5-104
5.1.8.13	Field Shelter	5-105
5.1.8.14	Vicinity Properties Support Facility	5-105
5.1.8.15	Training Facilities	5-105
5.1.8.16	Site Contaminated Water Balance	5-107
5.1.8.17	Design Criteria and Specifications	5-108
5.1.8.17.1	Applicable Codes and Standards	5-108
5.1.8.17.2	List of Specifications	5-108
5.1.8.18	Other Facilities Systems Analysis	5-109
5.2	Disposal Facility	5-109
5.2.1	General	5-109
5.2.2	Cell Siting	5-113
5.2.2.1	Functional Requirements	5-114
5.2.2.2	Performance Requirements	5-114
5.2.2.3	Performance Goals	5-114

TABLE OF CONTENTS (Continued)

NUMBER **PAGE**

5.2.2.4 Identification of Alternatives 5-116
5.2.2.5 Evaluation of Alternatives 5-116
5.2.2.6 Selection of the Preferred Alternative 5-117
5.2.2.7 Details of the Preferred Alternative 5-117
5.2.2.8 Technical Uncertainties 5-119

5.2.3 Cell Configuration/Optimization 5-119

5.2.3.1 Functional Requirements 5-119
5.2.3.2 Performance Requirements 5-120
5.2.3.3 Identification of Alternatives 5-120
5.2.3.4 Evaluation of Alternatives 5-121
5.2.3.5 Selection of the Preferred Alternatives 5-123
5.2.3.6 Details of the Preferred Alternative 5-123

5.2.3.6.1 CSS Cell 5-124
5.2.3.6.2 VIT Cell 5-127

5.2.3.7 Technical Uncertainties 5-127

5.2.4 Foundation 5-127

5.2.4.1 Functional Requirements 5-128
5.2.4.2 Performance Requirements 5-128
5.2.4.3 Identification of Alternatives 5-129
5.2.4.4 Evaluation of Alternatives 5-130
5.2.4.5 Selection of Preferred Alternative 5-131
5.2.4.6 Details of Preferred Alternative 5-131

5.2.4.6.1 CSS Cell 5-131

TABLE OF CONTENTS (Continued)

NUMBER **PAGE**

5.2.4.6.2 VIT Cell 5-132
5.2.4.6.3 Settlement and Slope Stability 5-132

5.2.4.7 Technical Uncertainties 5-133
5.2.4.8 Specifications 5-134

5.2.5 Liner and Leachate Collection and Removal Systems 5-134

5.2.5.1 General 5-134

5.2.5.1.1 Functional Requirements 5-134
5.2.5.1.2 Performance Requirements 5-134
5.2.5.1.3 Identification of Alternatives 5-135
5.2.5.1.4 Evaluation of Alternatives 5-135
5.2.5.1.5 Selection of the Preferred Alternative 5-135
5.2.5.1.6 Details of the Preferred Alternatives 5-135
5.2.5.1.7 Technical Uncertainties 5-136
5.2.5.1.8 Performance of Components 5-137
5.2.5.1.9 Design Criteria 5-137
5.2.5.1.10 Specifications 5-138

5.2.5.2 Liner Components and Configurations 5-138

5.2.5.2.1 Functional Requirements 5-138
5.2.5.2.2 Performance Requirements 5-138
5.2.5.2.3 Identification of Alternatives 5-139
5.2.5.2.4 Evaluation of Alternatives 5-139
5.2.5.2.5 Selection of the Preferred Alternatives 5-139
5.2.5.2.6 Details of the Preferred Alternatives 5-140
5.2.5.2.7 Technical Uncertainties 5-141

TABLE OF CONTENTS (Continued)

NUMBER PAGE

5.2.5.2.8 Performance of Components 5-141
5.2.5.2.9 Design Criteria 5-141
5.2.5.2.10 Specifications 5-142
5.2.5.2.11 Flexible Membrane Liners 5-142
5.2.5.2.12 Natural Material Liners 5-144

5.2.5.3 Leachate Collection and Removal System 5-148

5.2.5.3.1 Functional Requirements 5-148
5.2.5.3.2 Performance Requirements 5-149
5.2.5.3.3 Identification of Alternatives 5-149
5.2.5.3.4 Evaluation of Alternatives 5-149
5.2.5.3.5 Selection of the Preferred Alternatives 5-149
5.2.5.3.6 Details of the Preferred Alternatives 5-150
5.2.5.3.7 Technical Uncertainties 5-152
5.2.5.3.8 Performance of Components 5-153
5.2.5.3.9 Design Criteria 5-153
5.2.5.3.10 Specifications 5-156

5.2.6 Waste Placement 5-156

5.2.6.1 General 5-156

5.2.6.1.1 Functional Requirements 5-156
5.2.6.1.2 Performance Requirements 5-157

5.2.6.2 Placement Strategy 5-157

5.2.6.2.1 Alternative Evaluation 5-157
5.2.6.2.2 Details of Preferred Alternatives 5-158

TABLE OF CONTENTS (Continued)

NUMBER **PAGE**

5.2.6.2.3 Technical Uncertainties 5-160

5.2.6.3 Radon Control 5-161

5.2.6.3.1 Alternative Evaluation 5-161
5.2.6.3.2 Details of the Preferred Alternative 5-161
5.2.6.3.3 Technical Uncertainties 5-161

5.2.6.4 Design Criteria 5-162
5.2.6.5 Specifications 5-162

5.2.7 Waste Containment System 5-163

5.2.7.1 General 5-163
5.2.7.2 Cover 5-164

5.2.7.2.1 Cover Types 5-164
5.2.7.2.2 Cover as Radon Barrier 5-169
5.2.7.2.3 Cover for Erosion Control 5-172
5.2.7.2.4 Cover for Biointrusion Control 5-175
5.2.7.2.5 Cover as Infiltration Control 5-177
5.2.7.2.6 Cover As a Drain 5-180
5.2.7.2.7 Interim Cover for Dust Control 5-183

5.2.7.3 Perimeter Encapsulation 5-185

5.2.7.3.1 General 5-185
5.2.7.3.2 Erosion Protection - Side Slopes 5-187
5.2.7.3.3 Biointrusion Barrier 5-190
5.2.7.3.4 Side Slope Infiltration 5-191

TABLE OF CONTENTS (Continued)

NUMBER **PAGE**

5.2.7.3.5 Stability 5-193
5.2.7.3.6 Settlement 5-196

5.2.8 Cell Drainage/Water Management 5-197

5.2.8.1 General 5-197
5.2.8.2 Alternatives Evaluation 5-199
5.2.8.3 Details of Preferred Alternatives 5-199
5.2.8.4 Technical Uncertainties 5-201

5.2.9 Operation and Maintenance During Cell Construction 5-203

5.2.9.1 General 5-203
5.2.9.2 Alternatives Evaluation 5-204
5.2.9.3 Details of Preferred Alternatives 5-204
5.2.9.4 Technical Uncertainties 5-207

5.3 Treatment and Processing 5-207

5.3.1 General 5-207

5.3.1.1 Waste Characterization 5-209

5.3.1.1.1 Raffinate 5-209
5.3.1.1.2 Raffinate Pit Clay Bottom 5-210
5.3.1.1.3 Quarry Soils and Sludge 5-211
5.3.1.1.4 Surface Soils 5-211

5.3.1.2 Major Components of Treatment and Processing 5-211

TABLE OF CONTENTS (Continued)

NUMBER PAGE

5.3.2 Chemical Stabilization/Solidification 5-214

5.3.2.1 General 5-214
5.3.2.2 Functional Criteria 5-214
5.3.2.3 Performance Criteria 5-214
5.3.2.4 Regulatory Concerns 5-215
5.3.2.5 Plant Design and Process Components 5-216

5.3.2.5.1 Reagents 5-220
5.3.2.5.2 Material Preparation 5-220
5.3.2.5.3 Radon Emission Control 5-221
5.3.2.5.4 Component Storage System 5-221
5.3.2.5.5 Feed System 5-222
5.3.2.5.6 Mixing and Product Discharge System 5-222

5.3.2.6 Plant Location 5-223
5.3.2.7 Specifications 5-223

5.3.3 Vitrification Design 5-225

5.3.3.1 General 5-226
5.3.3.2 Functional Criteria 5-227
5.3.3.3 Performance Criteria 5-227
5.3.3.4 Regulatory Concerns 5-227

5.3.3.4.1 Toxicity Characteristic Leaching Procedure . . 5-228
5.3.3.4.2 Product Form 5-229
5.3.3.4.3 Air Emissions 5-230
5.3.3.4.4 Double Walled Piping 5-234
5.3.3.4.5 Treatment Residuals 5-234

TABLE OF CONTENTS (Continued)

NUMBER PAGE

5.3.3.4.6 Vitrified Product Strength 5-236

5.3.3.5 Plant and Process Components 5-236

5.3.3.5.1 Assumptions 5-236
5.3.3.5.2 Proactive Problem Prevention 5-238
5.3.3.5.3 Melter Circuits 5-239
5.3.3.5.4 Additives and Waste Mixtures 5-240
5.3.3.5.5 Material Preparation Circuits 5-242
5.3.3.5.6 Radon Emissions Control 5-244
5.3.3.5.7 Waste Storage and Mixing Circuits 5-244
5.3.3.5.8 Melter Feed Circuits 5-245
5.3.3.5.9 Product Discharge Circuit 5-245
5.3.3.5.10 Off-Gas Treatment Circuits 5-246

5.3.3.6 Plant Location 5-247
5.3.3.7 Specifications 5-248
5.3.3.8 Applicable Codes and Standards 5-250

5.3.4 Size Reduction 5-251

5.3.4.1 General 5-251
5.3.4.2 Performance and Functional Criteria 5-252
5.3.4.3 Regulatory Concerns 5-252
5.3.4.4 Debris Characterization 5-252
5.3.4.5 Identification of Alternatives 5-252
5.3.4.6 Technical Uncertainties 5-254
5.3.4.7 Specifications 5-254

5.3.5 Dewatering 5-254

TABLE OF CONTENTS (Continued)

NUMBER PAGE

5.3.5.1 General 5-254
5.3.5.2 Functional and Performance Criteria 5-255
5.3.5.3 Regulatory Concerns 5-256
5.3.5.4 Raffinate Sludge Characterization 5-257
5.3.5.5 Dewatering Design Components 5-257

5.3.5.5.1 Metal Separator (Optional) 5-258
5.3.5.5.2 Classifier (Optional) 5-258
5.3.5.5.3 Storage Device (Optional) 5-259
5.3.5.5.4 Reagents 5-260
5.3.5.5.5 Blender/Mixer (Optional) 5-262
5.3.5.5.6 Thickener 5-263

5.3.5.6 Dewatering Method 5-264

5.3.5.6.1 Dewatering Equipment for CSS Plant Feed . . 5-265
5.3.5.6.2 Dewatering Equipment for VIT Plant Feed . . 5-266

5.3.5.7 Radon Emissions Control 5-266
5.3.5.8 Technical Uncertainities 5-268
5.3.5.9 Product Discharge 5-268
5.3.5.10 Dewatering Facility Location 5-268
5.3.5.11 Specifications 5-269

5.3.6 Decontamination 5-269

5.3.6.1 General 5-269
5.3.6.2 Modified Value Engineering Session 5-271
5.3.6.3 Functional and Performance Criteria 5-273

TABLE OF CONTENTS (Continued)

NUMBER PAGE

5.3.6.3.1 Assumptions 5-273
5.3.6.3.2 Functional Requirements 5-274
5.3.6.3.3 Performance Requirements 5-274

5.3.6.4 Regulatory Concerns 5-274
5.3.6.5 Decontamination System 5-275
5.3.6.6 Uncertainties 5-278

5.3.7 Additional Treatments 5-279

5.3.7.1 General 5-279
5.3.7.2 Summary of Additional Treatments 5-279
5.3.7.3 Treatment Recommendations 5-283
5.3.7.4 Technical and Regulatory Uncertainties 5-284

5.4 Site Closure 5-285

5.4.1 General 5-285
5.4.2 Removal and Remediation of Temporary Support Facilities 5-288
5.4.3 Site Closure Road System 5-291
5.4.4 Site Reclamation 5-296

5.4.4.1 Revegetation 5-296
5.4.4.2 Site Security 5-301

5.4.5 Groundwater Monitoring Wells 5-302
5.4.6 Surface Runoff Controls 5-311
5.4.7 General Design Criteria, Drawings, and Specifications 5-314
5.4.8 Site Closure System Analysis 5-315

TABLE OF CONTENTS (Continued)

NUMBER PAGE

5.5 Long-Term Monitoring and Maintenance 5-318

5.5.1 General 5-318
5.5.2 Proposed ARARs (Preferred Alternative) 5-319
5.5.3 Details of Preferred Alternative 5-319

5.5.3.1 Routine Site Inspections 5-320
5.5.3.2 Groundwater Monitoring 5-321
5.5.3.3 Custodial Maintenance and Repair 5-321
5.5.3.4 Contingency Response 5-322

5.5.4 Technical Uncertainties 5-322
5.5.5 Operational Requirements 5-322

5 SITE DESIGN DESCRIPTIONS

5.1 General

The conceptual design encompasses a broad range of interactive designs in a total system for remediation of the Weldon Spring site. The methodology outlined in Section 3 has been followed throughout the following segments beginning with the functional and performance requirements. Section 5 delineates the design alternatives that were considered, the screening of the designs, and the detailing of the preferred design. The chemical stabilization/ solidification (CSS) waste treatment alternative (documented as the selected remedy in the *Record of Decision* (Ref. 4) [ROD]) will be used as the base case for each design, with any deviations noted for the design, in the event that the backup vitrification (VIT) technology is utilized.

The section is divided into similar groups of designs:

- General site designs: the temporary infrastructures built to implement the remediation of the site and the construction of the disposal cell.
- Disposal cell designs: items that make up the long-term disposal cell design.
- Treatment and processing designs: the treatment design alternatives identified in the *Remedial Investigation/Feasibility Study*, (RI/FS) (Ref. 74 and Ref. 148), along with other related and additional treatments required for portions of the waste prior to disposal in the on-site cell or release off site as noncontaminated material.
- Site closure: the sequence of closure activities and design of permanent features other than the disposal cell.
- Long-term monitoring and maintenance: a guideline for developing long-term plans for the site after remediation.

The operation and construction considerations for these designs will be described in Section 6, with long-term disposal cell operation and performance outlined in Section 8.

5.1.2 Waste Removal

5.1.2.1 General. Site remediation requires removal of contaminated material from specified locations within the Weldon Spring site and adjacent vicinity properties. Table 5.1.2-1 lists the types, estimated quantities and locations of these materials. Figures 5.1.2-1 and 5.1.2-2 show locations at the site and adjacent vicinity properties. As shown on the table, these materials have varying physical characteristics and reside in several areas; the major waste sites and types have been evaluated individually to ensure an appropriate overall removal design. Waste removal will be performed in compliance with Occupational Safety and Health Administration (OSHA) and other applicable regulations. Refer to Section 4 for all regulatory requirements applicable to the *Technical Information Document* (TID). Water control measures during removal activities are discussed in Section 5.1.6, Site Drainage.

5.1.2.2 Removal Plan

5.1.2.2.1 General. Plans have been developed to support the removal of waste materials from the various locations described in Section 2 and depicted in Figures 5.1.2-1 and 5.1.2-2. Waste removal is an integral component of the overall remedial action, especially in providing selected waste to the processing and treatment facilities. The contaminated materials include in-place soils and sediment, raffinate sludge, building foundations, underground utilities, and stockpiled materials at the material staging area (MSA), temporary storage area (TSA), the Ash Pond spoils area, soil stockpile areas, and the mulch pile. The stockpile areas contain material removed from the quarry (TSA), chemical plant building dismantlement and demolition (MSA and Ash Pond), excavated in-place soils (Ash Pond spoils area), soils within the footprints of the TSA and site water treatment plant (SWTP), and chipped and composted wood materials (mulch pile). Most of the wastes stored in Building 434 will also be removed and placed in the cell. Friable asbestos-containing material (ACM) must be removed from the ACM storage area; sludges from both the quarry and site water treatment plant facilities must also be removed. Removal plans have been developed and are discussed in the subsections below for each of the following major Weldon Spring Site Remedial Action Project (WSSRAP) material types:

- Contaminated soils (including soil stockpile areas).
- Foundations and underground utilities.
- TSA waste.
- Raffinate pit sludge.

- MSA waste.
- Vicinity properties soils.
- Water treatment plant waste.
- Waste from other areas (ACM storage, mulch pile, Building 434, and Ash Pond spoils area).

5.1.2.2.2 **Functional Requirement.** The functional requirement for removing the material types will be to minimize the spread of contamination, including radon and airborne particulate emissions. Other requirements include minimizing equipment quantities and reducing worker exposure to hazardous conditions.

5.1.2.2.3 **Performance Requirements.** Material-specific performance requirements are discussed in the following subsections. General performance requirements include:

- Flexibility and adaptability to remove various material types under differing site conditions.
- Capability to separate clean areas from contaminated areas and to control radon and airborne particulate emissions.
- Meeting required production rates.
- Minimizing waste generation.
- Reducing adverse public perception.
- Compatibility with health and safety requirements.
- Compliance with applicable regulations.

5.1.2.2.4 **Alternatives Evaluated.** Individual removal plans for each type of material were developed because different equipment and methods may be required for removing these disparate materials; location may also affect the types of removal equipment selected. A modified value engineering (MVE) approach was used to select preferred

alternatives (Ref. 71). Table 5.1.2-2 lists the removal alternatives considered for the various material types.

5.1.2.2.5 Preferred Alternative. Table 5.1.2-2 also shows the preferred alternative for the various types needing removal. Excluding the raffinate pit sludges, there is no preferred alternative for removing each type of material. Equipment will be selected based on specific site conditions, health and safety constraints, and production requirements. The subsections below provide more specific information.

5.1.2.2.6 Technical Uncertainties. Technical uncertainties are discussed for each material type in the subsections below, and in Section 6.1.2.4, Operational Uncertainties.

5.1.2.2.7 Contaminated Soils. Table 5.1.2-1 shows the material type and locations requiring removal. These locations can be grouped into the following general areas:

1. Chemical plant area
2. Ash Pond spoils area
3. South Dump
4. North Dump
5. Frog Pond
6. Raffinate pits (clay bottom, dikes and surrounding soils)
7. Temporary storage area
8. Various soil spoil areas

Figure 5.1.2-3 shows the approximate depths and boundaries of the contaminated soils to be removed (Ref. 4). Specific depths and boundaries will be defined during Title II design. The observational approach also applies to all removal operations because unexpected conditions, such as the presence of unknown debris and more extensive contamination, may be encountered. Removal of the soils requires the use of large construction equipment. Minimizing area disturbances will be important to reduce the likelihood of contaminant spread. The areas designated for material removal range from large surface areas, such as within the raffinate pits and Ash Pond, to relatively small areas such as Frog Pond.

Equipment was selected for soil removal based on the following criteria:

- The depth of the soil to be removed relative to the surface area. While a scraper may be suitable for removing soil over a wide area, scrapers are not an acceptable choice when only a narrow trench is required.

- The total volume of material to be removed from a given site. A large volume of soil will require more time for removal and may require a larger fleet of equipment or large-scale equipment, whereas a small volume of material in a given location may dictate other equipment.

- Physical constraints, including nearby impediments to excavation and removal such as adjacent facilities, and overhead obstacles such as power lines.

- The need to minimize the spread of contamination.

- The physical nature of the soil. Depending on soil conditions, excavation methods may require low-ground-pressure tracked excavators, keeping trucks above the excavation face, and pre-excavation preparation such as dozing material into piles or scarifying.

- The capability of selected equipment to successfully operate on several material types at varying depths, and thus reducing the variety and number of equipment pieces required.

No single criterion is of greater importance than another. Equipment must be matched to the various soil and site conditions, while limiting the number of equipment types required. MVE Table 5.1.2-3 summarizes results of the MVE session on equipment for removal of in-place contaminated soils, including the raffinate pit clay bottom and dikes. Equipment selection was based on the specific site conditions and the material to be removed.

Preferred equipment for the various site conditions is described below.

- Small, deep, isolated areas: backhoe removal.

- Small, shallow, isolated areas: front-end loader or backhoe removal.

- Large, deep areas: backhoe with tracks (wet conditions) and combination of self-loading scrapers, front-end loaders, and backhoes (dry conditions).

- Large, shallow areas: self-loading scraper.

The overriding concern in selecting a preferred method of removing the raffinate pit clay bottom is the ability of the bottom and subgrade material to support the equipment. Equipment workability on the clay bottom material is unknown because no samples of the clay bottom have been collected. If the clay bottom material is too soft or wet to allow efficient equipment operation, then additional preparatory steps will be needed prior to excavation. Operating methods have been selected for both wet and dry material conditions. MVE Table 5.1.2-4 presents the evaluation summary of the alternatives for stabilizing the raffinate pit clay bottom to support removal equipment.

If equipment can operate on the clay bottom and underlying soil, the preferred alternative consists of no subgrade preparation for the equipment, the use of normal earth-moving equipment such as backhoes and trucks, or dozing into piles and loading into trucks using a front-end loader.

If conditions do not allow equipment to work directly on the clay bottom or subgrade, gravel or geosynthetic roadways could be constructed to support equipment movement and operation. Installing roadways would significantly increase equipment workability without significantly impacting the schedule; the impact on the treatment process would also be minimal. A disadvantage is that the material used to construct the roadways may become contaminated, increasing the volume of waste requiring disposal. Additional equipment such as front-end loaders or scrapers would also be required to place the gravel base. Alternately, draglines operating from the pit perimeters could be used to remove material. Disadvantages include the need for long-boom equipment, poor control of contamination spread, numerous equipment set-ups and imprecise material removal resulting in possible overexcavation of clean material.

The impact on the types of excavation equipment resulting from deviations from anticipated site conditions will be minimal. Removal strategies can be easily modified to

accommodate potential deviations. Potential deviations are addressed in Section 6.1.3.4, Operational Uncertainties.

5.1.2.2.8 Foundations and Underground Utilities. Equipment for removing the building foundations and underground utilities was selected based on the following criteria:

- The depth of the soil to be removed relative to the surface area. Scrapers may be suitable for removing soil over a wide area, but are not effective in exposing foundations and underground piping in a narrow trench.

- The capability of a particular piece of equipment to successfully operate on several different material types and conditions, thereby reducing the variety and number of equipment pieces required. Contaminants in the process sewer lines may require a specific method of removal.

- The capability to cut or break concrete, piping, and embedded reinforcing bar into efficient, manageable sizes.

- The flexibility required to remove the various slab thicknesses, vertical footings, and foundations, as well as specialized concrete features such as sumps and stamping columns.

MVE Table 5.1.2-5 summarizes the results of the MVE session on foundation removal. Prior to loading and hauling, the building foundations will be reduced to rubble using a front-end loader. The selection of preferred methods is influenced by dust and contaminant control requirements, operational considerations, and public perception. Methods such as blasting and use of wrecking balls were rejected because of these concerns. Concrete removal methods used at the site recently were considered in the evaluation. The preferred alternative for rubblizing building foundations involves using equipment equipped with a hoe ram attachment. Advantages of this method include suitability for use on a wide variety of reinforced concrete structures such as slabs, footings, and other foundation features. In addition, adequate size control can be achieved without compromising worker health and safety. The major disadvantage of this method is that reinforcing bar must be cut using other methods such as a shear or cutting torch.

All methods for cutting or breaking the concrete into manageable sizes will require ancillary equipment for loading and hauling the rubble.

Potential deviations from expected conditions that could affect the preferred design include the presence of deep foundations not accessible by a hoe ram and large monolithic concrete structures not suitable for breakage using a hoe ram. The presence of chemically contaminated liquids and sludges could also affect equipment selection. These deviations can be managed by excavating deeply buried concrete prior to breakage; handling the large single pieces separately; and physical characterization of foundations to identify contaminated liquids and sludges. Table 5.1.2-6 summarizes the foundation types present. Figure 5.1.2-4 shows foundation locations and the main underground piping routes.

Several miscellaneous structures will require removal methods similar to those for foundations. The structures are primarily located within the building area and include asphalt and concrete roads and access ramps, sidewalks and pipe-rack support pedestals, asphalt and concrete slabs on grade, and asphalt parking lots.

MVE Table 5.1.2-7 presents the alternatives for underground utility removal. The method used to remove buried pipe and utilities from excavation trenches will be similar to the standard methods used to lay the lines. An overriding concern for this procedure is health and safety. Workers may need to access the trench bottoms to collect samples. This will require that all trenches meet regulatory standards pertaining to personnel entry. It may be possible to obtain necessary samples using the backhoe bucket, and eliminating the need to access the trench.

A backhoe is the preferred alternative for both trenching of clean material above the buried utility and removal of the utilities and adjacent contaminated soils. Advantages include the ability to excavate the soil and remove the utility using the same equipment. No disadvantages were identified, although different backhoes may be required for handling the clean soil and the contaminated waste. Impacts on the conceptual design due to potential deviations from expected conditions are minimal. The greatest impact on the design may be the need for multiple pieces of similar equipment to meet schedule requirements. Table 5.1.2-8 summarizes the known underground utility sizes and types present.

5.1.2.2.9 Temporary Storage Area Waste. Material removed previously is stockpiled (TSA, MSA); therefore, the evaluation criteria used to select preferred alternatives for removing stockpiled material are operational in nature. The ability to reclaim the waste at required rates, while maintaining health and safety standards, dominates the selection process.

As with in-place soils and sediments, the preferred alternative is a function of specific conditions. The alternatives evaluation summary is shown in MVE Table 5.1.2-9. The preferred alternatives for the various waste types are described below.

- Soils, chipped wood, small rubble (nominal 3 ft): front-end loader, when sufficient maneuvering room is available; backhoe in congested locations.

- Bulky and large-sized material: backhoe with grapple, if the stockpile is not too high and the waste material is suitable for a grapple. A crane may be needed if stockpile is too high.

- Individual large and heavy pieces: crane.

No potential deviations from expected conditions are foreseen because materials are characterized as they are stockpiled.

In addition to the stockpiles discussed above, excavated waste will be temporarily stockpiled until the disposal facility is ready to accept waste. The material to be stockpiled and the duration of storage will depend on the excavation sequence and remediation schedule. Equipment used to reclaim the waste will be similar to the equipment previously selected in this section.

The waste stockpiled at the TSA will consist of material removed from the quarry. The materials will be segregated into the material types defined below:

- Rock/concrete/rubble - 50,300 cu yd (yd^3)
- Sludge - 4,100 yd^3
- Fine-grained soils - 52,000 yd^3
- Nitroaromatic-contaminated material - 8,800 yd^3
- Chipped wood and grub - 5,300 yd^3

- Metals, including intact drums and containers - 10,500 yd^3

The quarry materials have not been removed; the quantities listed above are estimates.

Rubble: The 50,300 cu yd of rubble will serve as containment for the fine-grained soils, sludge, and nitroaromatic-contaminated materials. Rubble will range in size from 6 in. to 3 ft and will consist of materials not included in the other categories.

Sludge: The quarry sludge is comprised of material removed from the quarry pond. The sludge has not yet been characterized, but it is presumed to consist of fine-grained sediments transported to the pond from erosion caused by surface water runoff. Current plans are to place the sludges on top of the fine-grained soils stockpiled to a maximum depth of 2 ft; the sludges will also be processed through the treatment facility. A dozer will push the material into piles for removal by a front-end loader.

Fine-grained soils: The 52,000 cu yd of fine-grained soils are comprised of waste material less than 6 in. in size that is not included in the other waste categories. The fine-grained soils will be removed using a wheeled front-end loader or backhoe.

Nitroaromatic-contaminated materials: The nitroaromatic-contaminated materials are comprised of rubble and fine-grained soils that have been identified as containing nitroaromatic contaminants. Removal will be similar to removal of the rubble and fine-grained soils.

Chipped wood: The material contained in the chipped wood stockpile contains wood waste removed from the quarry, including clearing and grubbing material. Material will be most efficiently removed using a wheeled front-end loader.

Metals: The metals may include process equipment and vessels, piping, steel members and plates, reinforcing bar, ruptured drums, and intact drums and containers. A crane equipped with a grapple or electromagnet is the most versatile equipment to use for removal, excluding the intact pieces, because a wide range of material sizes may be present. Intact drums and containers will be stored in overpacks that could then be picked up with a forklift.

5.1.2.2.10 Raffinate Pits. This section addresses sludge removal; removal of the raffinate pit clay bottom is addressed in Section 5.1.2.2.7. Of the evaluation criteria identified

for raffinate sludge removal, the health and safety aspects of maintaining a water cover over the sludge and the difficulty of minimizing the spread of contaminants while handling the flowable sludge impact the selection process significantly. Table 5.1.2-10 identifies the quantities of water, sludge, and clay bottom material in each pit. Figure 5.1.2-5 presents Raffinate Pits 1, 2, 3, and 4 water depth and sludge thickness statistical data.

The physical nature of the raffinate pit sludges and the necessity of controlling radon and dust emissions are the main criteria for selecting removal techniques. Specific physical characteristics affecting removal are described below.

- The raffinate sludges are made up of extremely fine-grained wastes. While they are cohesive enough to allow core samples to be sliced with a knife, a limited amount of agitation will free the particles into a cohesionless mass presenting significant excavation and transportation problems.

- The moisture content of the sludges is very high (around 70% by dry weight basis). When agitated, the sludge/moisture combination results in a very flowable material that will require specific equipment for adequate removal and transport.

- Because of the fine particle size, dry sludges must be kept from exposure to the air to reduce spreading contamination through dust and other transfers. One of the most practical methods to eliminate both dust and radon emissions is to retain a water cover over sludges. While this satisfies the dust and radon emission control requirements, it complicates the excavation and removal process. Preliminary laboratory tests indicate that using only a water cover may not adequately control radon emissions during dredging. Further study and field tests are necessary to evaluate the best effective preventive measures for controlling radon emissions during sludge removal.

MVE Table 5.1.2-11 presents the raffinate sludge removal alternatives evaluation summary. The preferred removal and transportation alternative is a cutter-head dredge combined with a slurry pump and delivery pipeline to the waste treatment facility. Advantages of this system include: (1) flexibility in water management and material removal sequencing, (2) a continuous water cover that provides control of radon/dust emission and contaminant spread, (3) minimal production downtime required for movement between pits, and (4) controlled,

variable production rates. Disadvantages of this system are that (1) an alternate removal method is necessary for removing trash and debris; (2) additional dewatering is necessary since the process will increase the sludge water content. The dredge must be capable of removing sludge at a rate compatible with waste treatment plant production rates. Dredges are available with capacities that will accommodate the required rates for either the CSS or VIT waste treatment alternative.

As shown in MVE Table 5.1.2-12, it is anticipated that the raffinate sludge can be removed using a cutter-head dredge, and that the sludge will be pumped through a slurry pipeline to the dewatering facility. If either of these assumptions is incorrect, this method is fatally flawed. Vendors have evaluated existing sludge characteristics data and have indicated that the material is suitable for dredging and pumping. However, testing should be performed as part of the waste treatment plant pilot testing program to confirm removal capability and to develop final design criteria.

Other factors are necessary for the use of a cutter-head dredge are that enough water is available to control dust and radon emissions and that the treatment plant production rates can be met. Potential deviations from these conditions are unlikely, and the effect on the conceptual design would be minimal. Deviations and unexpected factors are addressed in Section 6.1.4.6, Operational Uncertainties.

Although no fatal flaws appear to exist with a dredging removal method, no field tests have been conducted to prove this concept. Therefore, other possible methods for removing the raffinate sludges have been considered. Several possible alternative methods are described below.

Sump Pump With Mechanical Collector. This system would consist of a submerged trash pump with pipe transport to the waste treatment plant. Some mechanical means, such as a Sauerman scraper or dragline, would be required to pull the sludge to the pump. This system has several negative features, including leaving some sludge on the pit bottom and pumping a substantial amount of excess water to the waste treatment plant. However, if this technique will work, the cutter-head dredge will also work while leaving less sludge in the pit bottom and producing less water.

Long-Boom Backhoe. This technique involves excavating the sludge using a long-boom backhoe from progressing benches of clean fill. After the water cover is removed, a long-boom backhoe would excavate the sludge and clay bottom down to clean material, initially working from the existing dike. At the completion of the first pass, clean fill would be placed where the sludge had been removed. The backhoe would then make another pass from this clean bench. This process would continue until all sludge is removed and the pit area is completely backfilled. One major concern is the slope angle of the sludge working face. Since the sludge is approximately 15 ft deep in Pit 3, the weight of the sludge could cause the material to seek a very flat angle of repose. Even using a backhoe with an extended reach, the amount of sludge available per pass would be small, significantly reducing the productivity of the removal operation. Controlling radon and dust on the excavation face would also be difficult.

Barge-Mounted Hydraulic Clamshell or Backhoe. Mounted on one barge, the clamshell would excavate sludge and place it into a single container mounted on a second barge. After the container was filled, the barge would propel it to the unloading dock, and the barge would return with an empty container to repeat the process. Although this would seem to present the fewest risks and would maintain the water cover, productivity may be too low to meet operational requirements.

Backhoe or Dragline on Dikes. This method involves constructing a dike across the pits and excavating the sludge with a backhoe or dragline from the existing and newly constructed dikes. Existing contaminated soil and broken concrete would be used to build the necessary dikes on which to operate the excavator and trucks. No driving of piles or plates would be allowed. The dikes would be removed along with the clay bottom material. Disadvantages include the mixing of sludge and dike material. Mixing of materials could result in unnecessary treatment of excess material or in not treating a portion of the sludge.

Solidify Raffinate In Place. After solidifying the raffinate in place, the treated sludge would be excavated using common earth moving equipment. While no specific investigation into suitable stabilizing materials has been performed for this study, commercial agents may be available that can stabilize the high-moisture-content sludges while they remain under the existing blanket of water. If this is correct, following mixing of the sludge and the stabilizing agent, the water over the stabilized sludge could be removed, and common excavation equipment could be used to remove the stabilized sludge. Water spray could be used to control dust during excavation and removal. Impacts on the alternative treatment methods are unknown.

Summary of Raffinate Removal Techniques. Material characteristics, pit configurations, and production requirements indicate that use of a cutter-head dredge would be the most acceptable excavation method. The barge-mounted excavator appears to be the most conservative of the other possible methods. Although the internal dikes have several disadvantages, they also provide excellent excavation capabilities. The progressive clean filling would be a satisfactory method only if the sludge could be placed at an acceptable slope angle.

5.1.2.2.11 Material Staging Area Waste and Debris. See Section 5.1.2.2.5 for equipment selection discussion. The removal methods for TSA stockpiled materials described in Section 5.1.2.3.1 are also applicable to the material types stockpiled at the MSA. Table 5.1.2-13 provides a listing of material types and quantities.

5.1.2.2.12 Vicinity Properties. See Section 5.1.2.2.5 for equipment selection discussion. Vicinity property material must be removed in a manner that facilitates transport on public roadways; the use of a scraper is excluded due to the potential for spreading contamination. Table 5.1.2-14 presents vicinity properties contaminant data. The vicinity properties contain contaminated soils similar to the site contaminated soils. The removal equipment discussed in Section 5.1.2.2.7 is also applicable to vicinity properties materials.

5.1.2.2.13 Water Treatment Plant Wastes. Sludge resulting from water treatment will be generated from three facilities:

- Quarry water treatment plant - sludge cake.
- Site water treatment plant Train 1 - sludge cake.
- Site water treatment plant Train 2 (in design) - brine.
- Mobile water treatment plant.

Material removal alternatives were not evaluated because the methods have already been incorporated into each facility design. Sludge cake will be stored in an elevated hopper with discharge at the bottom. The open space beneath the hopper can accommodate 20 cu yd roll-off containers; the hopper would empty into these containers. The brine will be stored in tanks and removed by pumping.

5.1.2.2.14 Waste from Other Areas. Wastes from other areas include:

- Mulch pile - chipped wood.
- Ash Pond spoils area (other soil, spoils pile) - soils; rubble.
- Asbestos-containing materials storage - friable asbestos-containing materials.
- Building 434 wastes.

See Section 5.1.2.2.7 for equipment selection discussion for the mulch pile and Ash Pond spoils area. This section describes acceptable removal equipment for the material types stored at these areas. Friable ACM is stored in closed containers at the ACM storage area. These containers cannot be moved while full because the structural integrity of the containers is not sufficient. Friable ACM removal operations will comply with applicable regulatory requirements.

Material volumes at each of the three areas are as follows:

- Mulch pile: 29,132 cu yd.
- ACM storage: 10,089 cu yd.
- Ash pond spoils: 206,069 cu yd.

Materials to be stockpiled at the Ash Pond spoils area originate from the following locations:

- Frog Pond (soils and sediments).
- North dump (soils).
- Chemical plant building area (soil and rubble).
- TSA and SWTP facility areas (soil).
- Raffinate pits area (soil).

All materials at the above locations must be removed and stockpiled at the Ash Pond spoils area to allow for support facilities and disposal cell construction.

5.1.2.2.15 Removal Sequence and Schedule. The removal sequence and schedule is based on information developed during an MVE session that specifically addressed the preparation of an integrated schedule for material removal, treatment of selected waste, and

placement in the disposal cell (Ref. 71). The removal is divided into five sequences, as shown in Figures 5.1.2-6 through 5.1.2-10, to facilitate the discussion below. The cost and scheduling document has also been developed based on this MVE.

Sequence 1. Material is removed and temporarily stockpiled to allow for construction of the TSA, the SWTP, the construction materials staging area (CMSA), the borrow source haul road, the waste treatment plant, and the Phase I disposal cell. The removed materials will be placed in interim storage at the Ash Pond spoils area. Figure 5.1.2-6 illustrates removal Sequence 1. Materials to be removed during this sequence include the following:

- North dump soils (removed for CMSA construction).
- Frog Pond soils (removed to prevent potential contamination of the borrow area haul road).
- Soils adjacent to the raffinate pits (east side of Raffinate Pit 3; removed for treatment facility construction).
- Soils, foundations, and underground piping in the chemical plant building area (removed for disposal cell construction).

Sequence 2. The facilities discussed in Sequence 1 have been constructed and treatment and placement of the waste within the disposal facility has begun. Dredging is underway in Raffinate Pit 4. Construction of the disposal cell Phase II is in progress. Figure 5.1.2-7 shows the material removal for Sequence 2. Materials to be removed include the following:

- MSA materials.
- TSA materials.
- Raffinate pit sludge and clay bottom.
- Ash Pond spoils area materials, as needed.
- Mulch pile materials, as needed.
- ACM storage area materials, as needed.
- Site and quarry water treatment plant sludges, as generated.

Sequence 3. Construction of disposal cell Phase I and II clean-fill dikes and foundations is complete. Placement of waste in Phase I continues. Phase III disposal cell construction does not begin until actual waste quantities to be placed have been more definitively assessed. The MSA must be removed as soon as all the waste material contained in the facility has been removed so that disposal cell construction can be completed. Figure 5.1.2-8 shows material removal and placement for Sequence 3. Materials to be removed include the following:

- MSA materials.
- TSA materials.
- Raffinate pit sludge and clay bottom.
- Ash Pond spoils area materials, as needed.
- Mulch pile materials, as needed.
- Miscellaneous ACM materials remaining.
- Site and quarry water treatment plant sludges, as generated.
- Building 434 wastes.

Sequence 4. Waste placement in Phase I has been completed, placement within Phase II begins, and Phase III disposal cell construction begins. All materials within the MSA and TSA have been removed; all raffinate pit sludges have been removed as well. During this sequence, all materials requiring treatment will be processed and the treatment facility dismantled. Figure 5.1.2-9 shows Sequence 4. Materials to be removed include the following:

- Vicinity property soils and sediments.
- Raffinate pit clay bottoms.
- Ash Pond spoils area materials, as needed.
- Mulch pile materials, as needed.
- Miscellaneous ACM materials remaining.
- Site and quarry water treatment plant sludges, as generated.

Sequence 5. Disposal cell Phase III construction has been completed, and material placement in Phase III begins. All contaminated vicinity property soils have been removed. The Ash Pond and south dump materials can be removed once the Ash Pond spoils area has been eliminated. Removal of support facilities and placement of the materials in the disposal facility can begin once the facilities are no longer needed. These facilities include drainage control structures (e.g., dikes and retention ponds), the TSA, the CMSA, the SWTP, haul roads,

including the quarry haul road, and construction staging materials (e.g., gravel used to provide a supporting base for equipment). The SWTP will be the last facility removed, because water treatment must continue until all other material has been removed and placed within the disposal cell.

Figure 5.1.2-10 illustrates Sequence 5. Materials to be removed include the following:

- Ash Pond and south dump soils and sediments, including buried debris, if any.
- Vicinity property soils and sediments, including buried debris, if any.
- Raffinate pit clay bottoms.
- Ash Pond spoils area materials, as needed.
- Mulch pile materials, as needed.
- Contaminated support facilities.
- Site and quarry water treatment plant sludges, as generated.

Waste removal schedules for the CSS and VIT treatment alternatives are presented in Figures 5.1.2-11 and 5.1.2-12, respectively. Other site activities that directly interact with waste removal activities are also shown. Several items that affect waste removal have been identified.

- The type of treatment process significantly impacts removal requirements. CSS treatment can be accomplished twice as fast as VIT. The selected process will determine requisite waste removal rates for all materials and areas.

- Each of the three disposal cell phases must be constructed in a single construction season.

- Removal of soils, foundations, and underground piping in the chemical plant building area can be accomplished within a construction season, provided material removal is staggered.

- Raffinate pit area soil removal and waste treatment plant construction start-up must be completed within two successive construction seasons.

- Waste must be removed from certain areas within set time frames or disposal cell construction will be delayed. For other areas (e.g., Ash Pond and south dump) stockpile removal is driven by material requirements for disposal cell placement.

- Removal of the raffinate pit sludges and clay bottom must be staggered to avoid schedule delays.

- Some contaminated vicinity property soils cannot be removed until cleanup of the Ash Pond and raffinate pits is completed, unless alternate arrangements are made for discharge of surface water from the raffinate pit and Ash Pond drainages.

5.1.2.3 **Design Criteria and Specifications.** Design criteria and specifications have been identified for removal of the materials described in Section 5.1.2. Applicable codes and standards include:

- 29 CFR Part 26, Subpart P, Excavations.

- 40 CFR Part 61, *National Emission Standards for Hazardous Air Pollutants.*

- 40 CFR 262, *Standards Applicable to Generators of Hazardous Waste.*

- 40 CFR 264, *EPA Standards for o/o of Hazardous Waste Treatment, Storage, and Disposal Facilities.*

- 10 CSR 25-7.264, *Rules Applicable to Owners/Operators of Hazardous Waste Facilities.*

- 10 CSR 10-6.170, *Restriction of Particulate Matter to the Ambient Air Beyond the Premises of Origin.*

- Applicable DOE orders including 6430.1A, *General Design Criteria*, radon, airborne particulate, and vehicle exhaust restrictions.

- WSSRAP Health and Safety Plan requirements.

- WSSRAP *On-Site Transportation Manual for Hazardous Materials* (Ref. 70).

- WSSRAP *Radiological Control Manual and Implementation Plan* (Ref. 37).

Removal of materials will continue until all defined contaminant-specific cleanup criteria have been achieved. The specific cleanup criteria will be specified in the *Record of Decision*. Removal will proceed to prevent visible particulate matter from going beyond site boundaries as specified in 10 CSR 10-6.170. Following waste removal, the remediated areas will be regraded and vegetated. Requirements are addressed further in Section 5.11, Site Closure.

40 CFR 264 will be applicable for all contaminated soils materials, and other wastes identified as RCRA characteristic hazardous waste and will be handled, stored, and treated as a hazardous waste.

Table 5.1.2-15 lists applicable design criteria requirements for waste removal, and Table 5.1.2-16 lists specification requirements. The tables list general requirements; material-specific requirements are addressed below. Potential deviations from expected conditions and additional data collection requirements, if any, are addressed in Section 6.1.2.4, Operational Uncertainties.

Vicinity Properties. Contaminated soil removal at the vicinity properties will be similar to contaminated soil removal on site because both require strict controls for dust and radon. In addition, there may be some additional environmental protection requirements because of site specific conditions.

Foundations and Underground Utilities. Foundations and underground utilities design criteria will be predicated upon the results of a field characterization survey including:

- Liquid and sludge - location, types, and quantities. The liquids and sludges will be characterized and removed prior to foundation and underground utilities removal.

- Materials characterization - location, depths, types, and sizes.

- As-built information from building and dismantling subcontracts, including locations of installed underground utilities and capped floor penetrations.

- Material sizing restrictions.

Raffinate Sludge. Final design criteria will be dependent upon results of pilot testing for dredging, slurrying, dewatering, and treatment. Additional data needs include the items listed below. These data can be obtained during Title II design activities:

- In-place material isopachs.
- Material composition data.
- Production rates needed to meet dewatering, SWTP, and treatment facility requirements.
- Minimum or maximum water cover requirements for equipment and emission control.
- Stability analysis of berms; identification of acceptable stability measures, if needed.

Raffinate Pit Clay Bottom. The clay bottom will not be characterized until the sludge and water have been removed. The moisture content of the clay bottom will then be assessed to ascertain whether additional stability measures are required to support the equipment. An updated dike stability analysis will also be required so that stability during remedial action activities can be assessed. Heavy equipment will be operating on, or adjacent to, the dikes during sludge and clay bottom removal.

Stockpiled Material. Stockpiled material will consist of soils, sludge, metals, rubble, and containers of various sizes. Pile configuration will also vary. Stockpile as-built information identifying material types, sizes, quantities and storage configurations (e.g., stockpile height, slope, access; container sizes, stack height; weights) will be required.

5.1.3 Waste Handling and Transportation

5.1.3.1 General. The removed materials described in Section 5.1.2, Waste Removal, will require transport. The ultimate destination is the disposal facility, but some

material will be transported to interim locations for processing or stockpiling prior to final deposition.

Material handling and transport must be coordinated with waste removal. Figures 5.1.2-1 and 5.1.2-2 show the locations of the various materials. The subsections below describe facilities that will be needed to support material handling and transportation, present the handling and transportation plan, discuss the transportation sequence and schedule, and addresses pertinent design criteria and specifications. Some material such as structural steel has been identified as potentially suitable for decontamination and off-site release. Section 5.3.6, Decontamination addresses this topic.

5.1.3.2 **Facilities.** Support facility requirements for waste material handling and transportation operations are minimal. The availability of adequate haul roads is the most important factor for material transport; Section 5.1.5, Site Roads, describes the infrastructure needed to facilitate transport.

Temporary equipment decontamination facilities must be constructed at the vicinity properties waste removal locations. The primary requirement is to contain and collect wastewater that may be generated from the wash unit. At a minimum, a gravel pad underlain by an impervious liner will be needed. Decontamination will be accomplished using a portable water pressure unit. Temporary staging areas may need to be established at some locations. At a minimum, these areas should have gravel surfaces over a prepared subgrade. No alternatives were evaluated because the main requirement is to minimally impact the areas, thus constraining selection of more permanent construction methods.

5.1.3.3 Handling and Transportation Plan

5.1.3.3.1 **General.** As with waste removal, handling and transportation requirements are a function of material type and location. Material must also be handled and transported so that area disturbances and contamination spread are minimized. In addition, material removal and handling are closely interrelated; equipment suitable for use in removing material can also transfer the material to the transport equipment. In the case of scrapers, the removal equipment serves as both the handling and transport equipment. The selected handling equipment will be contingent upon the removal and transport equipment and is only peripherally examined below.

The material types listed below were evaluated separately to account for differences in material characteristics:

- Soils.
- Concrete and rubble.
- Raffinate pit sludge.
- Other wastes - containerized; metals; mulch; treatment products.

5.1.3.3.2 **Functional Requirements.** The functional requirement will be to handle the materials removed and then convey the materials to and from designated interim and final locations.

5.1.3.3.3 **Performance Requirements.** The performance requirements used to compare alternative material handling and transport methods for each waste type include:

- Operational flexibility and mobility - selected equipment should be capable of handling and transporting a wide variety of material with differing characteristics so that equipment quantity is minimized.

- Emission control capability - selected equipment should lend itself to control of radon and airborne particulate emissions.

- Maintenance minimization - selected equipment should be low maintenance.

- Implementability ease - selected equipment should not require an extensive design or procurement process.

5.1.3.3.4 **Evaluation of Alternatives.** Three methods have been identified as potential alternatives for material transport:

- Slurry pipeline.
- Conveyor system.
- Mobile equipment fleet.

A slurry pipeline transports particulates through a pipeline by suspending the material in a liquid; solids content must be less than 60%. The particulates that can be transported are usually constrained by size. Particles greater than 3 in. in diameter are generally not suitable for slurry pipeline transport. Earthen materials are usually amenable to slurry transport; concrete, rubble and metal are not considered a typical material for slurry pipeline transport and would require considerable processing to reduce the material to an acceptable particle size. Another consideration is that water must be added to create the slurry. The slurry would then require dewatering, and the water would require treatment at a water treatment plant.

A conveyor system generally consists of a motor-driven continuous belt that travels over idlers and rollers suspended from a steel framing system. All material types could be transported by a conveyor system provided that maximum size and moisture content criteria are not exceeded.

A mobile equipment fleet would consist of dump trucks, flat-bed trucks, and scrapers. A mobile equipment fleet could transport all material types while minimizing size and moisture content constraints.

5.1.3.3.5 Preferred Alternative. The subsections below describe the preferred alternative for each of the material types of interest. The preferred alternative for transport of all materials excluding the raffinate sludge is the mobile equipment fleet. For the raffinate sludge, a slurry pipeline is preferred.

5.1.3.3.6 Technical Uncertainties. There are no technical uncertainties associated with a mobile equipment fleet. Potential deviations for the selected method for removal of raffinate sludge are a function of material pumpability. Should the material prove unpumpable, excavation by backhoe would be selected (see Section 5.1.2.2.4); transport would then be by mobile equipment fleet.

5.1.3.3.7 Contaminated Soils. The contaminated soils can be transported by all three alternatives: slurry pipeline, conveyor system, and mobile equipment fleet. The preferred option is the mobile equipment fleet.

The advantage to a slurry pipeline is that radon and airborne particulate emissions are controlled and equipment requirements are reduced. However, these considerations are more

than offset by the need for water addition, removal, and treatment. Multiple slurry pipelines would also be required because of the numerous contaminant source locations and the several interim storage sites needed prior to final material placement within the disposal cell.

Multiple conveyor systems would also be required. Design requirements are also relatively complex because minimum vehicle clearance heights would be needed wherever a road was crossed. The entire conveyor would also need to be enclosed for emission control and to prevent losing material. Chemical- and water-based emission suppressants probably could not be used because of the damaging effects on the mechanical equipment.

The mobile equipment fleet has numerous advantages including:

- Removal and handling equipment could be used for transport if haul distances are short.
- Extensive design and procurement requirements are not necessary; conventional construction equipment such haul trucks, scrapers, and front-end loaders could be used.
- Emission control suppressants can be used.
- Flexibility is greatly enhanced; fleet size can be easily modified to meet changing requirements.

Potential deviations are negligible because of the high degree of flexibility that a mobile equipment fleet offers.

5.1.3.3.8 Concrete and Rubble. The concrete and rubble could be potentially transported by all three alternatives; however, a slurry pipeline is not an appropriate selection given the physical characteristics of concrete and rubble. Considerable processing would be necessary to reduce the material to a suitable size. The majority of the material would also tend to be a larger particulate size which would increase equipment maintenance requirements because of mechanical wear and tear. Finally, concrete and rubble materials are not normally transported by slurry.

The conveyor system is suitable for transporting concrete and rubble; some material preprocessing would still be required to help ensure that the maximum material size the equipment could convey was not exceeded. Radon and particulate control is still a concern as the reduction process would result in generation of some finer-grained particulates. As with soils, multiple systems and enclosure would still be needed.

A mobile equipment fleet is the preferred alternative for concrete and rubble for the same reasons it is the preferred alternative for soils. An additional advantage is that a wide range of material sizes can be accommodated. For example, oversized pieces could be transported using flatbed trucks.

5.1.3.3.9 Raffinate Sludge. The slurry pipeline is the preferred alternative for transporting the raffinate sludge. The initial moisture content of the sludge already exceeds 60%. The slurry pipeline could be connected directly to the dredge equipment and could transport the sludge directly to the dewatering facility. Emissions control would be optimized. The dewatering facility will be located adjacent to the raffinate pits; piping requirements are minimal and the pipeline will not cross over any roads.

A conveyor system is not appropriate for transporting the sludge from the pits to the dewatering facility because of the high moisture content of the sludge. A mobile equipment fleet could be used, but special efforts would be needed to prevent contaminant release. Containers, truck bed liners, or tanker trucks would be required, and material handling requirements would be increased. A circuitous haul route relative to the slurry pipeline would also be necessary, thus increasing haul cycles.

5.1.3.3.10 Other Wastes. A mobile equipment fleet is also the preferred method of transporting other site wastes. Containerized wastes cannot be transported by a conveyor system because of size and weight limitations. In any case, the need for multiple systems, enclosures, and vehicle clearances, as described in previous sections, renders the conveyor system infeasible. A slurry pipeline is also not appropriate for the same reasons described in the sections above. Table 5.1.3-1 lists the preferred handling and transport equipment for the various waste types.

5.1.3.3.11 Transportation Sequence and Schedule. With the exception of the raffinate sludge, the various materials will be transported by a mobile equipment fleet. The sludge will be transported by slurry pipeline. The remaining material will be handled and

transported by conventional equipment including backhoes equipped with grapples, front-end loaders, dozers, cranes, forklifts, scrapers, and trucks. In most instances, trucks will be used for material hauling, unless the haul distance dictates otherwise. Scrapers and the selected handling equipment may be more suitable for transporting material over shorter distances.

The handling and transportation sequencing and schedule requirements are based on the proposed waste removal sequence and schedules described in Section 5.1.2.3.7. The mobile transport equipment will use the site haul roads described in Section 5.1.5 to convey the waste materials. As with waste removal, handling and transportation must be coordinated closely with waste treatment and waste placement requirements.

The material handling and transportation schedules must coincide with the removal schedules presented in Figures 5.1.2-11 and 5.1.2-12. The general routes for material transport corresponding to the removal sequence are contained in Section 5.1.5.

5.1.3.4 Design Criteria and Specifications. Design criteria and a specification listing have been developed for handling and transport of the materials identified in Sections 5.1.3.3.1 through 5.1.3.3.4. Applicable codes and standards include:

- Friable asbestos handling and transportation regulations.
- Applicable DOE orders including radon, airborne particulate and vehicle exhaust emission restrictions.
- U.S. Department of Transportation regulations (applicable to vicinity properties).
- *On-Site Transportation Manual for Hazardous Materials* (Ref. 70).
- Occupational Safety and Health Administration.
- *Resource Conservation Recovery Act* (RCRA).

Table 5.1.3-2 lists applicable design criteria requirements for transport, and Table 5.1.3-3 lists specification requirements. The primary criteria is to handle and transport material so that radon and airborne particulate emissions are within acceptable limits. Acceptable emission

control methods include transport in closed containers equipped with metal or tarp lids, keeping material wet, and spraying earthen materials with a crusting agent. Equipment decontamination will be in accordance with existing WSSRAP procedures.

5.1.4 Construction Materials Staging Area

5.1.4.1 General. A construction material staging area (CMSA) will be required for the temporary storage of construction materials during the construction of the Weldon Spring on-site disposal facility. The CMSA will be used to store limited amounts of uncontaminated construction materials such as clay borrow soils, gravels, riprap, synthetic liners, piping, and prefabricated drainage structures.

5.1.4.1.1 Functional Requirements. The CMSA serves as a surge facility to guarantee material availability and to accommodate delivery peaks for either the CSS or VIT alternatives, since both alternatives require the construction of a disposal facility.

5.1.4.1.2 Performance Requirements. The performance criteria of the CMSA are:

- Ease of material accessibility.
- Adequate storage capacity.
- Adequate foundation for the material storage piles.
- Access from off-site roads.
- Control of storm water run-on and runoff.
- Erosion and sediment control.
- Appropriate surfacing to minimize dust and rutting.
- Adequate protection of stored materials.

To ensure that the CMSA meets these requirements, Sections 5.1.4.2 through 5.1.4.6 evaluate various alternatives for the location, design criteria, site preparation, surfacing, and drainage control for the CMSA. Alternatives were evaluated using the modified value engineering approach, and a preferred alternative was selected.

Section 5.1.4.7, CMSA System Analysis, identifies design interfaces with other site activities for each of the preferred alternatives and provides solutions to any anticipated problems.

5.1.4.2 Location and Layout of Storage Area. Thirteen tentative locations for the CMSA were evaluated; these are shown on Figures 5.1.4-1 through 5.1.4-3. Each location was evaluated based on its capacity to store the various types of construction materials (i.e., off-site clay borrow, on-site clay borrow, and synthetic and natural construction materials). During this conceptual design process, the anticipated volume requirements for materials storage were established (see Waste Removal Section 5.1.2). Based on these preliminary estimates, the space requirements for on-site clay borrow and synthetic and natural materials were established:

	Estimated Design Storage Volume
On-site Clay Borrow	
• Assume additional 5 ft of excavation in the disposal cell siting area	267,000 yd^3
Design Volume: use 100% of clay materials	(10 acres required CMSA reserve storage)
Synthetic Materials Needed for Phase I of Cell Construction	
• FML - 212,000 yd^2	
• Pipe - 6000 lf	
• Sumps - 14 each	
• Trailer/work area/roads	
• Geonets and geofabrics	
Estimated quantity of synthetic materials required for Phase I:	110,000 ft^2
Design area for synthetic materials: use 100% of materials	(3 acres required CMSA reserve storage)
Natural Construction Materials Needed for Phase I of Cell Construction	
• Leachate collection granular materials	
• Filter material	
• Drain material	
• Riprap	

Estimated quantity of natural material for Phase I	112,000 yd^3
Design volume for natural materials use 10% of total materials	(12,000 yd^3 required CMSA reserve storage)

The CMSA must be sized to store these amounts to guarantee material availability during construction, and must be designed to adequately support the loading generated by the stored materials. All materials must be accessible by equipment for loading and unloading.

The disposal cell construction will require the storage of three types of material: off-site clay borrow, on-site clay borrow, and synthetic and natural construction materials. Because these materials have different storage requirements, the preferred storage locations for each material were determined independently. MVE Table 5.1.4-1 (Items 1, 2 and 3) shows the alternative CMSA locations for storing the three types of materials. Both on-site and off-site storage locations were considered. Criteria for evaluating the alternative storage locations are also listed. The criteria were the same for all materials, but the weighing factors changed for each material type. Worker safety, adequacy of storage area size, ease of recovery, ease of land acquisition, and minimization of impacts on other activities were the most heavily weighted criteria for the selection process.

5.1.4.2.1 Off-Site Clay Borrow Storage.

Evaluation of Alternatives.

MVE Table 5.1.4-1 lists the advantages and disadvantages of the on-site and off-site alternative storage locations for off-site clay borrow storage. The location with the most significant advantages is the borrow source location itself. The efficiency of both excavating and storing material in the same general location minimizes operational and maintenance costs, delivery distance, congestion, and maximizes worker safety. The disadvantages are the distance to the disposal facility for retrieving the borrow material and the close proximity to Francis Howell High School.

The area north of Ash Pond can easily be acquired for project use and is more convenient for retrieval of stored material. The disadvantages are the consumption of site space and the double handling of material that would be required if the off-site clay borrow was stored in this area.

Using highway department property (Missouri Department of Conservation [MDOC]-South) would not interfere with site operations, thereby increasing worker safety. The property also is conveniently located for recovery of stored material. The disadvantages are that independent processing equipment is required for processing, and that, although land availability for project use is high, the area will require additional site research to develop.

Other locations such as the marshalling yard, disposal cell siting area, Army property, MDOC-North, south of the raffinate pits, and in the raffinate pits were also considered as potential storage locations. However, disadvantages such as recovery distances, interference with disposal cell construction, land availability problems, sensitive areas, and inadequate size outweigh the minimal advantages of each of these alternative storage sites.

Selection and Details of the Preferred Alternative

The off-site borrow source is the preferred alternative for off-site clay borrow storage. This location allows the same earthmoving equipment used to excavate the borrow material to process and handle this material. In addition, the borrow material could be delivered directly from the borrow source to the disposal cell, without being unloaded at an intermediate staging facility, thereby eliminates the need to handle the material twice.

Technical Uncertainties

MVE Table 5.1.4-2 shows the application and use of the observational method for storing the off-site clay material at the borrow source. Potential deviations to the expected condition are that clay materials may be brought to the disposal cell too fast or too slowly, and room to store and process material may not be adequate. Table 5.1.4-3, Item 1, lists the data requirements for each area of technical uncertainty. During final design, the anticipated or most likely quantities and delivery rates will be established. In addition, the final design values outlined above will determine the actual size required for the storage area. An alternative off-site clay borrow storage area may need to be studied if the primary borrow source area is not large enough to adequately handle both the borrow operations and storage requirements.

5.1.4.2.2 On-Site Clay Borrow Storage and Synthetic and Natural Materials Storage.

Evaluation of Alternatives

MVE Table 5.1.4-1 (Items 2 and 3) lists the advantages and disadvantages of the storage alternatives for the on-site clay borrow and synthetic and natural materials. The location for storing the on-site clay borrow with the most advantages, if the on-site clay borrow must be stockpiled prior to clean-fill dike construction, is the area north of Ash Pond. This area is readily available, the borrow material is stored on site, and the location is convenient for material recovery and delivery because of its proximity to the disposal cell. The disadvantages of this alternative are the consumption of site space and possible interference with other on-site activities.

The location of MDOC-South minimizes interference with on-site activities, provides better worker safety, and has a short haul and recovery distance. The disadvantages of using an off-site storage location for on-site clay borrow are related to transporting large quantities of soil off site that would need to be scanned for contamination. An additional disadvantage is that the area itself is potentially contaminated.

The area north of Ash Pond also has the most significant advantages for the synthetic and natural materials. The on-site location provides a more secure storage area than any off-site option. A short haul distance to the disposal cell construction area provides for convenient recovery of materials. The disadvantages of this alternative are that it consumes valuable site space and interferes with on-site activities. The MDOC-South location minimizes interferences with on-site activities and is convenient for recovery due to the short haul route. The disadvantage of this location is that it requires additional site research and development.

Other storage alternatives such as the marshalling yard, Army property, MDOC-North, the off-site borrow source, the raffinate pits and no storage, were also considered. However, the disadvantages of adverse public perceptions, land availability problems, impacts on other site activities, and difficulty in delivering and recovering the material outweighed the minimal advantages of each of these alternative storage sites.

Selection and Details of the Preferred Alternatives

The area north of Ash Pond within the chemical plant boundaries is the preferred alternative for storing the on-site clay borrow and the synthetic and natural materials. As a second option, the synthetic and natural materials could be stored at MDOC-South if more room for the on-site clay borrow storage is needed. A sketch of the CMSA occupying the northern part of the site is shown on Figure 5.1.4-4 to illustrate specific design concepts. This figure shows the preferred location and presents the preferred layout for material storage. The advantage of storing the on-site clay borrow on the western portion of the CMSA and storing the natural and synthetics on the eastern portion is that supply trucks delivering natural and synthetic materials can enter the CMSA and unload without interfering with the on-site clay borrow operations.

Technical Uncertainties

MVE Table 5.1.4-2 demonstrates the application and use of the observational method for storing the on-site clay borrow north of Ash Pond. Potential deviations from anticipated conditions include: (1) the storage capacity available is not sufficient; (2) the majority of clean material could be excavated from the disposal cell footprint and placed directly in the CFD rather than being stockpiled first and then placed; (3) most of the material excavated from the cell footprint is contaminated or becomes contaminated, and additional on-site storage capacity is needed. Because of the contaminated and uncontaminated soil volume contingency, the location of the synthetic and natural materials staging area may not be determined until the final design stage when the timing of the construction of the clean-fill dikes is known. It would be desirable to excavate the 5 ft of clay borrow from within the cell footprint and use it for construction of the CFD. If this occurs, a major portion of the area north of Ash Pond will become available. The additional space could then be used for other site activities. MVE Table 5.1.4-3 shows the additional data needs for the technical uncertainties described above.

5.1.4.3 Site Preparation. The area north of Ash Pond has been characterized, and contamination is present. All contamination must be removed before constructing the CMSA.

Identification of Alternatives

Three alternative sequence of activities were developed for CMSA site preparation. Each alternative lists different methods for: (1) providing erosion protection around the perimeter of the CMSA, (2) isolating contaminated material including diverting and detaining contaminated soil runoff, (3) removing contaminated soil from the CMSA, and (4) clearing, grubbing and grading.

Criteria evaluating the alternative site preparation methods included:

- Worker safety.
- Public perception.
- Impacts on cell construction.
- Impacts on CMSA operation.
- Effective use of the CMSA.

MVE Table 5.1.4-1 (Item 4) lists the relative weights of these criteria. In addition, the general WSSRAP criteria of feasibility, health and safety, and environmental risk were also considered.

Evaluation of Alternatives

MVE Table 5.1.4-1 describes the three alternatives for the CMSA site preparation. The more significant advantages and disadvantages of each alternative are listed below.

The advantages of Alternative 1 are that (1) the majority of clearing and grubbing work will be completed before the time-consuming removal of contaminated material begins, and (2) clearing uncontaminated wooded areas provides workers a larger, safer environment for removing contaminated materials. The main disadvantage is that the clearing and grubbing of uncontaminated materials would take place in areas surrounding areas of contamination. Special care must be taken to ensure that the contaminated material is isolated from the surrounding clean areas.

The main advantage of Alternative 2 is that, once the contaminated material is removed, cleared portions of the CMSA can be used for storing clean materials. If it is then determined

that the CMSA requires less area than originally estimated, the remaining area could be used for other activities. This is one of the main advantages of the preferred CMSA location. However, since most of the potential CMSA locations are in heavily wooded areas, removal of contaminated material from those areas could pose a hazard to workers if clearing and grubbing are not completed first.

Alternative 3 would decrease the mulch pile storage requirements because areas which are not used for materials staging would be left intact. However, since site space is limited, it is likely that any remaining cleared area would be needed for other disposal cell construction activities. Also, if additional storage space is needed, the operation would require lead time to clear additional portions, possibly delaying cell construction. This alternative has the added disadvantage that workers would have to work in a wooded area to remove the contaminated materials. Like Alternative 2, Alternative 3 would pose a greater worker safety hazard than Alternative 1.

Selection and Details of the Preferred Alternative

The preferred alternative for site preparation is Alternative 1, which involves clearing and grubbing uncontaminated areas and then removing any contaminated material via a dedicated haul road. Straw bales will be used to isolate contaminated areas from clean areas, and will be used to direct contaminated runoff to diversion ditches. All three alternatives considered provide erosion protection around the perimeter of the CMSA and isolation of contaminated areas. However, the preferred alternative will provide greater worker safety than the other alternatives, because workers will have a clear, safe environment for removing contaminated materials from the CMSA site.

Technical Uncertainties

MVE Table 5.1.4-2 shows the results of the application of the observational method to the site preparation preferred alternative. Tight controls will minimize the spreading of contamination. Excavation and removal of contaminated materials should start from the highest elevation and continue downgrade, preventing contaminated runoff discharge onto newly cleared, uncontaminated areas. Erosion control measures will be inspected and maintained routinely during the excavation of contaminated materials to ensure adequate erosion control. If contamination spreads, erosion protection measures will be replaced and surrounding areas will

be cleaned. If more contamination is encountered at the CMSA location, it will be removed before storing uncontaminated materials. MVE Table 5.1.4-3 lists items necessary to better define these areas of uncertainty. Since potential contamination of CMSA erosion protection measures is a concern, it is desirable to provide emergency erosion protection material near or on the CMSA.

5.1.4.4 Surfacing. A CMSA interior road system and material storage yard is needed for staging operations and for providing all-weather access for deliveries from the off-site borrow source to the disposal facility. These facilities must have appropriate subgrade, road section, and surface course to minimize dust and rutting and to support design vehicle loading. Appropriate road sections are described in Section 5.1.5, Site Roads. This section describes the selection process for an appropriate surface course for the different areas of the CMSA.

Identification of Alternatives

As discussed in Section 5.1.4.2 and Section 5.1.4.4, the CMSA includes three distinct areas:

1. On-site clay borrow storage and staging area.
2. Synthetic and natural construction materials storage and staging yard.
3. Interior roadway network.

MVE Table 5.1.4-1 (Item 5) lists alternative surface materials for the synthetic and natural material storage areas and for the interior roadway network. Because of the similar load support and traffic access requirements of these areas, the evaluation of surface material alternatives for these areas used identical criteria and criteria weighing factors. Among the most heavily weighted criteria were worker safety, performance of the surface, public perception, dust control, and impacts on CMSA operations. While the CMSA will not pose the hazard of contaminated dust on interior roads, dust control is critical to good public perception, general cleanliness of the operation, and meeting Missouri dust control regulations. Potential impacts of the surface material on CMSA operations were considered to: (1) minimize roadway construction time to allow staging operations to begin on schedule and (2) allow for the possibility of moving roads to reduce the size of the CMSA, if less material than originally estimated is required to construct the disposal cell.

MVE Table 5.1.4-1 (Item 6) lists alternative surface materials for the on-site clay borrow storage area. The alternatives are the same as those for the other areas: gravel, asphalt, Portland cement concrete, dirt, and an oil/rock mix. However, due to the variable nature of the clay borrow stockpile, the alternatives were evaluated only subjectively, without assigning weighing factors to the criteria.

Evaluation of Alternatives

The advantages and disadvantages of each surface material alternative are listed in MVE Table 5.1.4-1. Gravel offers the most significant advantages for the synthetic and natural materials storage yard and the interior roadway network. Gravel is readily available and requires no curing time. No special construction equipment, such as asphalt pavers or concrete mixers, is needed. Gravel will provide a good foundation for the stockpiled materials and good erosion and dust control for the interior roadway network.

Gravel, asphalt, concrete, and oil/rock surfaces resist rutting and erosion. A dirt surface is considered slightly inferior because of the greater potential for erosion and rutting. For dust control, asphalt, concrete, and oil/rock surfaces are rated as excellent, and a dirt surface is considered poor. The evaluation also concluded that the public would not have a favorable perception of dirt roads.

The major disadvantage of the concrete surface is the curing time required, which might interfere with cell construction, and the additional costs. Asphalt surfaces also require special equipment and some curing time. Dirt and gravel are the easiest surfaces to construct and will have little impact on CMSA operations.

Regarding surface performance, the oil/rock surface was considered to be inferior to the other alternatives because it may require major maintenance after heavy equipment (especially track equipment) passes over the surface. Asphalt and Portland cement will also require major maintenance after being subjected to heavy construction traffic loading for some time, even though these surfaces exhibit excellent performance.

The nature of the on-site clay borrow stockpile will require a temporary surface material that is easily moved to allow for an increase or reduction in the size of the stockpile. For this reason, a dirt surface has the most advantages for the on-site clay borrow storage area. While

the dirt surface will require the most dust control measures and may exhibit extensive rutting, the anticipated variations of the clay borrow stockpile area are not amenable to a more permanent surface material.

Selection and Details of the Preferred Alternative

Gravel is the preferred surface for the CMSA synthetic and natural materials storage yard and the interior roadway system. Dirt is the preferred surface for the clay borrow storage and staging areas. Compared to asphalt and concrete, gravel is easier to place, contains no contaminants, and would have little effect on CMSA operations. Gravel will control dust and perform better than a dirt surface in the CMSA roadway system and the synthetic and natural materials staging area. However, like asphalt, concrete, and oil/rock material, gravel is considered too permanent for the surface of the on-site clay borrow staging area.

Technical Uncertainties

MVE Table 5.1.4-2 illustrates potential deviations from the expected conditions for the two preferred CMSA surfacing materials. The probability that the gravel surface will not adequately support the vehicle loads, with reasonable tolerances, is very low. However, if the gravel surface exhibits excessive rutting, the gravel surface could be replaced by an asphalt surface to reduce rutting and to improve dust control. In either case, it is imperative that the gravel and subgrade material be compacted to specifications. Otherwise, rutting will occur regardless of the quality of surface material.

5.1.4.5 Surface Drainage Control. As stated in Section 5.1.4.1, one performance requirement of the CMSA design is to provide erosion and sediment control and to control storm water run-on and runoff.

Identification of Alternatives

Surface drainage control for the CMSA will generally require erosion protection. Run-on drainage will have to be diverted around the CMSA. Runoff drainage will be collected and discharged at an approved point to prevent erosion and sediment runoff. Criteria used for evaluating erosion protection are shown in MVE Table 5.1.4-1 (Item 7). Worker safety was the

highest weighted criterion. Performance of the erosion control methods, impacts on CMSA operations, and public perception were also highly rated.

Evaluation of Alternatives

MVE Table 5.1.4-1 (Item 7) lists the advantages and disadvantages of the erosion protection and surface drainage control alternatives for the CMSA. The most significant advantages of a particular type of erosion protection depend upon the drainage area and the topographic features of the CMSA. Hydroseeding, mulching, and erosion control matting provide excellent protection on both level terrain and steep slopes, require little maintenance, and would not impact CMSA operations. Straw bales are easy to install, maintain, and replace; are generally used on drainage areas of 0.5 acres or less, but do not perform well on steep slopes (Ref. 18). Silt fences also do not perform well on steep slopes and should not be used where the drainage area exceeds 0.5 acre per 100 ft of fence (Ref. 18). Diversion ditches or channels and check dams can be used for drainage control on large areas and would be the most advantageous if high sediment runoff is anticipated. However, the need for flexibility to accommodate the varying storage quantity requirements in the CMSA make fixed ditches and dams within the CMSA less desirable. Similarly, the large area required to contain the design runoff in sedimentation basins is a disadvantage, even though the basins can contain runoff from large areas. Riprap in drainage channels should be used where necessary to accommodate high flow velocities.

Selection and Details of the Preferred Alternatives

The preferred alternative for erosion protection and surface drainage control is to use a combination of straw bales, hydroseeding, grass-lined diversion ditches, erosion control matting, and sedimentation basins. These temporary erosion protection devices can be easily added, removed, and customized for any changes or variations encountered at the CMSA. Because some of the erosion control devices (e.g., straw bales and silt fences) are easily installed and removed, they may be used to control drainage in small areas, such as the small contaminated areas before these are cleaned. Riprap may also be used in selected spots that require greater erosion protection, such as the on-site clay borrow storage area. Regardless of the erosion protection and surface drainage control measures used, the devices will require frequent inspection (especially after every substantial storm) and minor maintenance to remove accumulated sediment.

Technical Uncertainties

MVE Table 5.1.4-2, Item 7, lists the technical uncertainties affecting the selection of erosion protection and surface drainage control measures. As stated in Section 5.1.4.3, the potential for CMSA erosion protection devices becoming contaminated is a concern. For this reason and the slight possibility that erosion protection measures could fail, emergency erosion protection devices should be stored near the CMSA. For the preferred on-site CMSA alternative, it will be necessary to develop a site storage plan showing maximum storage capacities of different areas of the CMSA so that erosion protection devices can be stored accordingly.

5.1.4.6 Design Criteria and Specifications. The specifications required to build the CMSA include:

- Site Preparation
- Earthwork
- Aggregate Base
- Chain Link Fences and Gates
- Seeding and Sodding
- Concrete
- Water Supply
- Electrical Power Distribution
- Structural Steel and Miscellaneous Metal
- Erosion and Sediment control

The general design criteria for the CMSA can be divided into the seven specific areas discussed in the following subsections.

5.1.4.6.1 Level Areas and Equipment Access for Material Storage Piles. The level areas will be designed to provide sufficient area, bearing capacity, and structural stability to accommodate separate stockpiles of soil and rock materials and access for loading and unloading materials. Gravel surfacing will be used. Slopes and surfaces will be designed to minimize surface erosion and maximize trafficability. Storm water run-on will diverted away from the CMSA to prevent contaminating stored materials (see Section 5.1.4.3).

5.1.4.6.2 Access Roads. As stated in Section 5.1.4.4, the surface material for the CMSA internal roadway system and all access roadways between the CMSA and off-site public roads will be gravel. Section 5.1.5, Site Roads, describes the design parameters and the selection process for design criteria for on-site roads. These design criteria will also be used for the CMSA internal roadway system and access roads. It is assumed that the CMSA must be designed to support off-highway vehicle loads. Road profiles will follow the existing ground where possible, and an attempt will be made to balance cut and fill quantities.

5.1.4.6.3 Staging Yard for Piping and Drainage Structures. The gravel staging yard will be designed to provide a sufficiently large level area with the required bearing and structural capacity to accommodate loading and unloading of equipment as well as units of piping, stacked and blocked pipe, and precast drainage structures, as needed for disposal cell construction. Slopes and surfaces will be designed to minimize surface erosion and maximize trafficability. Precautionary measures will be taken to prevent storm water run-on.

5.1.4.6.4 Access Control Trailer. An access control trailer will be designed and/or procured by the PMC. A stable compacted gravel base will be provided for the trailer. Electric and water utilities could be provided for future connection.

5.1.4.6.5 Equipment Tool Shed Area. An equipment tool shed area will be provided for storing hand tools, small power tools, construction markers, testing equipment, and other equipment necessary for disposal cell construction. A stable compacted gravel base will be provided in the equipment tool shed area. Subcontractors will be responsible for providing their own equipment tool shed. Electric and water utilities could be provided for future connections.

5.1.4.6.6 Storm Water Run-on and Runoff Control. Diversion ditches will be designed to convey the 10-year, 24-hour storm event. All conveyance systems will have a minimum of 0.5 ft of freeboard as specified in the *Surface Water and Erosion Control Report* (Ref. 36). Discharge rates will be determined using procedures recommended in *Design Storm Criteria Assessment* (Ref. 42). Silt fences, sediment traps, siltation basins, and other erosion control structures will be designed to minimize soil erosion and to comply with requirements of National Pollutant Discharge Elimination System (NPDES) permit standards for runoff during construction and remediation activities as identified in the *Surface Water and Erosion Control*

Report (Ref. 36). Section 5.1.4.5, Surface Drainage Control, contains additional information about storm water and erosion control.

5.1.4.6.7 Fencing and Gates. Access to the CMSA, including the pipe yard, equipment tool shed area, and trailers, will be restricted by a temporary construction fence with a lockable gate. If the CMSA is contained within the Weldon Spring site controlled area, fencing around the CMSA will not be necessary.

5.1.4.7 CMSA System Analysis. The CMSA system analysis must demonstrate that it will contain sufficient material stockpiles to offset delivery and construction peaks that may be encountered during the construction of the disposal facility. The general operation of the CMSA will involve the arrival of delivery trucks loaded with synthetic and natural materials to be used for disposal cell construction. The on-site clay borrow stockpile operation will involve the excavation of clean clay borrow from the disposal cell and the transportation of clay borrow material by truck to the CMSA. The disposal cell clean clay is expected to be excavated at one time, thereby using the maximum space allocated for the on-site clay borrow. The major design restrictions and uncertainties regarding the general operations of the CMSA are:

(1) Unknown amount of on-site uncontaminated clay borrow.

(2) Fixed size of on-site CMSA.

(3) Restrictions on access to the CMSA, particularly for vehicles traveling between the disposal cell and the CMSA (scanning and decontamination requirements).

(4) Unknown amount of contaminated soil in on-site CMSA location.

If the CMSA is located off site, additional considerations include (1) defining boundaries so that the area is large enough to accommodate the storage requirements of both clay borrow from the disposal cell footprint and synthetic and natural construction materials, (2) obtaining the necessary permits from land owners, and (3) evaluating access routes and possible additional scanning and decontamination requirements for travel between the CMSA and chemical plant site.

5.1.5 Site Roads

5.1.5.1 General. The chemical plant is located near U.S. Highway 40/61 adjacent to Missouri State Route 94. On State Route D, just north of the chemical plant, is the main entrance to August A. Busch Conservation Area, which is also located north of the chemical plant's boundary. Missouri State Route 94 and Highway D are asphalt surfaced rural highways that serve the communities westward. A traffic study (Ref. 43) evaluated the proposed traffic volumes and characteristics generated on site and on entering and leaving the chemical plant and raffinate pit areas. The public roadway system will not be disturbed during site remediation, except for construction workers and employees going to and from work and delivery trucks hauling cement, fly ash, gravel, sand, and similar materials for cell construction and operation of the treatment plant. Remediation will require the transportation of waste and new construction materials to and from various locations on site. Waste materials will be transported for treatment, stockpiling or staging, and disposal. Construction materials will be transported from off-site borrow areas (via a dedicated haul road), from on-site staging areas, and to construction areas. Access to construction areas on site, other than the site roadway system, will be the construction subcontractor's responsibility. Section 5.1.5.2, Site Roadway System, discusses how the on-site transportation plan provides for the delivery of both clean and contaminated material to the disposal cell. Dedicated clean and dirty roads will prevent cross-contamination. The temporary road system will change and evolve throughout site remediation. The permanent site road system is discussed in Section 5.4, Site Closure, which addresses the roads that will be needed after completion of remedial action.

Site road locations and traffic patterns are dependent upon the activities related to the following *Conceptual Design Report* (CDR) tasks:

- CMSA
- Borrow materials
- Waste removal
- Disposal facility
- Site drainage
- Waste handling and transportation
- Waste treatment and processing
- Site closure

The conceptual design of the roadway system for the CSS alternative will be done in three phases, producing a larger cell than the VIT alternative, which would be done in two phases. The following information is relevant to both alternatives for the conceptual design of site roads:

- Existing locations of waste materials.
- Locations (and possibly configurations) to and from which waste materials will be transported for treatment, stockpiling, staging, and/or disposal.
- The frequency of haul cycles, waste removal schedule, and the type of equipment used for excavating and hauling.
- Volume of treated material, locations to which the material will be transported, frequency of haul cycles, and treatment production rates and schedules.
- Location and configuration of the CMSA, types and quantities of construction materials, and delivery haul cycles and schedules.
- Siting and configuration of the disposal cell, construction schedule, and phasing and waste placement schedule and phasing.
- Location of off-site borrow areas.
- Design life and weather conditions.
- Operation and maintenance during operations, closure, and post closure.
- Quality assurance/quality control (QA/QC) procedures.

Functional Requirement

The site road systems plan must include provisions for a well organized traffic network for the efficient transportation of construction materials and waste. Separate clean and dirty

roads will prevent cross-contamination of clean and contaminated materials and will minimize contamination spreading.

Performance Requirements

The performance requirements of the site roads are:

- Design the on-site road system so that construction materials and waste can be transported efficiently.
- Provide adequate roadway widths for safety and efficiency.
- Provide access from existing public roadways.
- Control storm water run-on and runoff from site roads.
- Provide both temporary and permanent erosion and sediment control for site roads.
- Provide appropriate subgrade, road section, and surface course to minimize dust and rutting and support design vehicle loading.
- Provide dedicated clean and dirty haul roads.

Where applicable, the site roads design incorporates the *Missouri Standard Specifications for Highway Construction* (Ref. 44), the *Missouri Standard Plans for Highway Construction* (Ref. 45), and the *St. Louis County Standard Specifications for Highway Construction* (Ref. 46).

5.1.5.2 Site Roadway System. To evaluate and conceptually design the site roads within the chemical plant boundary, it was necessary to address the following topics:

- Road layout for the proposed disposal cell construction phases.
- Road preparation.
- Road surfacing.

A summary of the conceptual design criteria and specification outline is included in Section 5.1.5.5, and Section 5.1.5.6, System Analysis, evaluates the interaction of other remedial action designs that may be affected by the site road design.

Identification of Alternatives

Variables in the selection of site roadway system alternatives are the number and locations of access to public roads and the method of preventing cross-contamination of clean and dirty materials. MVE Table 5.1.5-1, Results of Modified Value Engineering: Site Roads Layout, lists the four alternatives evaluated for site access locations and the two alternatives for prevention of cross-contamination. Each alternative for site access includes the three existing access locations. These alternatives differ from each other in the location of a fourth off-site access location.

MVE Table 5.1.5-1 also lists criteria for evaluating the site roads layout alternatives. The most heavily weighted criteria were the separation of clean and contaminated materials and vehicles, the proximity of access locations to existing public roadways, the need for easy access to off-site borrow areas, and providing a safe and efficient road system.

Evaluation of Alternatives

Based on the criteria in MVE Table 5.1.5-1, the designation of separate clean and dirty roads is the only viable alternative for the prevention of cross-contamination of contaminated and uncontaminated materials. For good public perception, access to the chemical plant from off-site roads should be directly from Missouri State Route 94. The *Traffic Study for the WSSRAP* (Ref. 43) recommends that access to the site by trucks hauling construction material be directly from Missouri State Route 94 rather than via Route D. In addition, these deliveries could be at off-peak hours to reduce congestion and ensure maximum safety for students at Francis Howell High School. This recommendation is the result of traffic impact analyses indicating that Route D carries a significant amount of area traffic.

As shown in MVE Table 5.1.5-1, the main advantages of having a north access, in addition to the three existing access locations, are (1) vehicles delivering material from the off-site borrow area have a short route to the CMSA, and (2) heavy equipment from the off-site

borrow area enters the site through an access different from that used by employees. A fourth access location will require additional security.

Selection of the Preferred Alternative

The preferred alternative is to designate clean and dirty roads and to provide four access locations to public roads (see Figure 5.1.5-1):

1. Employee, contractor, and subcontractor access for personnel at the existing main entrance from Missouri State Route 94 or the access to the subcontractor parking lot.

2. Haul road from quarry (existing south entrance).

3. Water treatment plant access (existing access from Route A).

4. Construction material hauling entrance for access between the CMSA and the off-site borrow area, using existing abandoned roadbed which runs from Missouri State Route 94 westward to the CMSA (new north access).

Details of the Preferred Alternative

The four access locations were chosen for the following reasons: (1) the main entrance, south entrance, and SWTP entrance already exist; (2) personnel and heavy equipment traffic can be separated by access location, thereby reducing the potential for congestion at access locations used by heavy construction equipment; (3) equipment transporting contaminated material can be directed toward the decontamination pad near the south access without approaching clean exits, (4) the north entrance facilitates travel between the CMSA and off-site borrow area; and (5) all access locations lead to Missouri State Route 94, mitigating the impacts and concerns over the use of State Route D.

The designation of clean and dirty roads minimizes the contamination of equipment, maximizes worker safety, and provides adequate operation. By using dirty roads, all vehicles that transport contaminated materials can be directed to decontamination facilities and kept away from access locations used by personnel and uncontaminated equipment.

The on-site roads consist of the following categories:

- Clean roads for vehicles entering the site to deliver material to the CMSA. Vehicles will enter the site at the north access and will remain on clean roads while traveling within the site. These vehicles will not require decontamination as long as they are limited to the CMSA area.

- Clean roads for vehicles that must travel throughout the site to various locations. These roads will be used for transporting clean material from on-site stockpiles for disposal cell construction and for delivering cement and fly ash to the CSS treatment plant.

- Dirty roads dedicated to vehicles hauling contaminated waste material for treatment, stockpiling or staging, and disposal.

Roads within the disposal facility area and ramps leading from site roads to the disposal cell will be designed as a part of the disposal facility (Section 5.2). Vehicles transporting clean material to the cell will enter and exit the disposal cell area via clean ramps which lead to a clean site road. This road either will be designated outside the controlled area or will require a decontamination check. All other vehicles entering the disposal cell area must enter and exit on dirty ramps and travel only on designated dirty site roads. If a vehicle transporting clean material to the cell comes into contact with contaminated material, it must exit the cell on a dirty ramp.

A continuous clean path around the site perimeter will be constructed so that clean vehicles can circulate throughout the site without encountering dirty roads. Any clean vehicle that comes into contact with contaminated material or travels on a dirty road will be considered contaminated and must then travel only on designated dirty roads. Trucks carrying contaminated materials must pass through a decontamination facility before traveling on clean roads or exiting the site.

Technical Uncertainties

MVE Table 5.1.5-2 shows the application of the Observational Method to the site roads layout and access location alternatives. The table indicates that if all construction vehicles

entering the site must be scanned before they exit, a decontamination pad will be needed at the north access for vehicles traveling between the off-site borrow and the CMSA.

In MVE Table 5.1.5-3, data needs are listed for each technical uncertainty. The uncertainty to be resolved is whether or not clean construction equipment may enter and exit the site without passing through a decontamination facility.

5.1.5.2.1 Transportation Plan During Phase I Construction (CSS alternative). Figure 5.1.5-1, Existing Roadway System, shows the location of Missouri State Route 94, and the layout of existing roads within the chemical plant boundary. Wherever feasible, existing alignment will be followed in order to promote cut and fill balancing. New routes will be developed where old roads do not exist or where existing roads do not provide efficient transportation between origins and destinations. Prior to Phase I construction of the disposal facility, contaminated material will be removed from several areas throughout the site (see Figure 5.1.5-2 for areas of contamination). This material will be temporarily stored at the Ash Pond spoils area or the MSA. Contaminated material in the chemical plant area will be removed. Therefore, dirty roads will be required to traverse the chemical plant areas and to transport materials from this area to the MSA and to the Ash Pond spoils area. Because material in the area east of Raffinate Pit 3 will be removed during this stage, a dirty road also must enter this area. Figure 5.1.5-3, Construction of Disposal Cell - End of Sequence 1, shows the locations of both the clean and dirty roads required during Phase I of disposal facility construction.

Figure 5.1.5-1, Existing Roadway System, shows an existing north-south road between Buildings 201 and 408, an east-west road between Buildings 201 and 103, and a north-south road between Buildings 413 and 428. These site roads will be designated dirty roads for travel within the southern portion of the chemical plant area. Travel between the chemical plant and the Ash Pond spoils area and MSA will be accomplished via an existing road east of the MSA and an existing road south of the Ash Pond spoil area. Another existing road north of Raffinate Pit 1 will be used to enter the area east of Raffinate Pits 3 and 4.

Vehicles transporting clean material or uncontaminated water should have a continuous clean path around the site perimeter. This road will also allow for inspection of the site security function. To provide a continuous path, the existing road which turns east as it rounds the southern end of Raffinate Pit 4 (see Figure 5.1.5-3) must be extended to the south, along the

west boundary of the TSA. This road will meet two other clean roads at the southern access. One road leads to the TSA transfer station, and the other continues north along existing roads east of the SWTP. To continue the clean route around the site perimeter, a new clean road will be constructed along the east side of the disposal cell area. Figure 5.1.5-3 shows that the path of this new road connects the area north of the SWTP to an existing road which leads to the CMSA. Existing site roads north of the CMSA and along the west site boundary complete the clean perimeter route.

Three other existing site roads will be designated clean at this stage. One will provide access from the main entrance to the administrative buildings. The second will provide access from the decontamination pad southwest of the SWTP to Route A outside the site boundary. The third will connect the off-site borrow haul road to the CMSA.

5.1.5.2.2 Transportation Plan During Phase II Construction (CSS alternative). Figures 5.1.5-4 and 5.1.5-5 show the layout of site roads during Phase II construction of the disposal facility. New designated dirty site roads will be needed for travel between the disposal cell and the waste treatment facility and sludge dewatering plant. The CSS processing plant is located north and west of Raffinate Pit 1. Figures 5.1.5-4 and 5.1.5-5 show how dirty roads in these areas lead to a ramp over the disposal cell clean-fill dike. Two ramps from the dirty site road west of the disposal cell meet in the Phase I area to allow waste placement in Phase I without contaminating the clean Phase II foundation construction. Section 5.2, Disposal Facility, discusses the design of these ramps.

In Sequence 2 and Sequence 3 of disposal cell construction, sludge and foundation material will be removed from Raffinate Pit 4. Therefore, a new dirty road will be constructed from the existing road south of Ash Pond to access Raffinate Pit 4. Another new dirty road west of Raffinate Pits 1 and 2 connects the waste treatment facility with the TSA. It should also be noted that many of the dirty roads shown in Figure 5.1.5-3, Construction of Disposal Cell - End of Sequence 1, have been removed and are not shown in Figures 5.1.5-4 and 5.1.5-5.

During Phase II construction, clean roads will have the same layout as they did during Phase I construction. The only difference is that in order to provide clean access to the cell for vehicles transporting clean cover materials, a ramp will be constructed from the clean site road east of the disposal cell to the top of the CFD on the east side. This ramp is shown on both Figures 5.1.5-4 and 5.1.5-5. If a vehicle transporting cover material to the cell comes into

contact with contaminated material, it must exit the disposal cell area via the dirty ramp on the west side of the cell.

5.1.5.2.3 Transportation Plan During Closure Phase Construction (CSS alternative). Figure 5.1.5-6 shows the layout of site roads during construction of the clean-fill dike closure phase. Dirty roads connect the disposal facility to the waste treatment facility. Most of the other dirty roads depicted in Figure 5.1.5-5 have been demolished and added to the disposal cell by the end of Sequence 4. Figure 5.1.5-7 shows the layout of site roads prior to completion of the closure phase. A dirty ramp will be constructed to allow waste placement during the closure phase after the clean-fill dike encloses the cell. Most temporary storage and waste treatment facilities and the dirty site roads leading to them will be removed by the end of Sequence 5 of disposal cell construction. Clean site roads will remain for post-closure operations (see Figure 5.1.5-8).

5.1.5.2.4 Transportation Plan During Phase I & II Construction (VIT alternative). Layout of site roads during the construction of the VIT cell will be similar to the CSS cell layout. The site roads will traverse around the VIT cell in the same fashion as the CSS cell. However, the VIT cell will be constructed in only two phases. Phase I will be placing waste similar to that of Phase I of the CSS alternative. Phase II will be completion of the CFD around the waste similar to that of Phase III of the CSS alternative. Figure 5.1.5-9 shows the final road layout of the VIT cell when completed.

5.1.5.2.5 Access to Vicinity Properties. Figure 5.1.5-10 shows the locations of contaminated vicinity properties to be remediated. Access to vicinity properties will be primarily via existing public roadways or existing roadbeds near the chemical plant boundary. Table 5.1.5-4 lists the primary means of access to each of the vicinity properties shown in Figure 5.1.5-10.

Where existing roads do not provide access directly to vicinity properties, dirt roads will be constructed to connect the vicinity properties with existing roads. Gravel roads were considered unnecessary for travel to vicinity properties, due to the relatively low use and short design life of these roads.

5.1.5.2.6 Off-Site Borrow Haul Route. Remediation of the Weldon Spring chemical plant site will require using and transporting uncontaminated clay borrow from an off-

site borrow source. As shown in Figure 5.1.5-11, the proposed off-site clay borrow is located southeast of Francis Howell High School, approximately 1.5 mi from the site of the proposed disposal facility. Off-site clay borrow material will be used in the construction of the disposal cell's radon barrier and perimeter clean-fill dikes. It was necessary to determine a preferred transport method, including a haul route alignment and a Missouri State Route 94 crossing for the designated route.

Performance Requirements

The performance requirements of the borrow haul method and haul route are:

- To deliver material from the borrow source to the disposal cell (both locations assumed fixed).
- To meet the required quantity and schedule for borrow material (approximately 2 million yd^3 over a two-year to four-year period).
- To allow for a winter shut-down period plus 30 days of additional shutdown per year due to inclement weather.
- To accommodate the restrictions on haul vehicles entering the site, such as scanning and decontamination requirements.

Identification of Alternatives

The alternatives studied for the transportation of material from the off-site borrow source to the disposal facility are listed in MVE Table 5.1.5-5. They are: (1) off-highway transport vehicles, (2) a conveyor system, (3) highway transport vehicles using a designated haul road, and (4) highway transport vehicles using existing public roads. It was determined that both off-highway and highway transport vehicles would use the same haul road alignment. Therefore, the alternatives listed in MVE Table 5.1.5-6 for the Missouri State Route 94 crossing are an above- or below-grade conveyor crossing and an above- or below-grade truck crossing.

Details of the alternatives are presented in Figures 5.1.5-11 through 5.1.5-17. Figure 5.1.5-11 shows two possible haul road alignments for the haul vehicle alternative. Two

possible conveyor system alignments are shown on Figure 5.1.5-12. Figures 5.1.5-13 and 5.1.5-14 show plan views of the two Missouri State Route 94 crossing alternatives which correspond to the haul road alignments on Figure 5.1.5-11. Typical borrow haul road sections and sections through the Missouri State Route 94 vehicle crossing appear on Figures 5.1.5-15 and 5.1.5-16, respectively. Figure 5.1.5-17 illustrates a typical conveyor section and a section through the underground conveyor crossing of Missouri State Route 94.

MVE Table 5.1.5-5 lists 14 criteria used to evaluate haul method alternatives. Among those considered to be most important were safety, reliability, minimal impact to on-site activity, low operation and maintenance cost, simplified permitting process, and mud and dust control. A secondary evaluation led to the inclusion of two new criteria. These were the ability of small or minority business contractors to use the haul method, and whether or not the haul method is a proven effective system for this application. The alternatives for the Missouri State Route 94 crossing were compared with respect to public safety, simplicity of permitting process, public perception, and initial cost.

Evaluation of Alternatives

The four alternative haul methods were evaluated with respect to each criterion, considering the relative importance of the criteria. As a result, the alternatives were assigned the ranking shown in MVE Table 5.1.5-5. The table lists the advantages and disadvantages associated with each alternative. Many of the advantages of off-highway vehicles are associated with the relatively low number of haul cycles needed to deliver the material. This lowers cost, increases safety, and minimizes congestion and necessary decontamination of equipment. The main disadvantage of using off-highway vehicles is that small businesses may not be able to provide the equipment. The conveyor system has many of the same advantages as the off-highway vehicles, especially with regard to reduced congestion and minimal scanning and decontamination of equipment. However, the conveyor system is not flexible, and because there is no backup, hauling would cease completely if the system failed. If highway vehicles are used, the designated haul road would not have to be as wide or require as thick a pavement section as necessary for off-highway trucks. Small businesses are also likely to have this type of equipment. Requiring highway vehicles to use public roadways was considered a poor alternative. Not only does it have the disadvantages associated with a large fleet of vehicles, but it requires longer haul cycles and poses certain hazards due to interaction with public traffic.

MVE Table 5.1.5-6 lists the final rank and advantages and disadvantages of each of the four Missouri State Route 94 crossing alternatives. Below-grade crossings ranked higher than above grade crossings because of increased public safety and better public perception. While above-ground crossings are less costly and are easier to construct, the alignment location is limited due to sight distance requirements on Missouri State Route 94.

In addition to the above four alternatives, an at-grade haul road passing beneath Missouri State Route 94 was considered. The major disadvantage, which eliminated this as a viable alternative, is that the design speed of 55 mph would require very long transitional ramps and require additional highway right-of-way. Due to the time constraints of cell construction, it was determined that the overpass over the at-grade haul road would delay the remedial action considerably, whereas the other alternatives, due to the relatively minor impacts on Missouri State Route 94, could be implemented in a timely fashion.

Selection of Preferred Alternative

The results of the evaluation indicate that there are two viable alternatives for transporting material from the borrow source to the site. These are haul vehicles using a designated haul road or a conveyor system. If haul vehicles are used, either off-highway or highway vehicles are viable. Both highway and off-highway vehicles would use the same haul route alignment and right-of-way. The Missouri State Route 94 crossing would also have the same design for both types of vehicles. If a conveyor system is used, the haul route alignment would be different, and the Missouri State Route 94 crossing would probably be narrower than the truck crossing.

Details of the Preferred Alternative

MVE Table 5.1.5-5 indicates that the highest ranked alternative is to use off-highway vehicles. However, due to the advantages of the conveyor system and highway vehicles, the final proposed plan for the haul method and Missouri State Route 94 crossing is to allow contractors to bid using either haul vehicles or a conveyor system to transport the material. This would allow a subcontractor to provide a system that is most effective for the operation. The bidding documents would include:

- Haul road alignment with right-of-way.
- Conveyor alignment with right-of-way and State approved Missouri State Route 94 undercrossing location.
- Location and design for haul unit undercrossing.
- Drainage specifications.
- Necessary permits.
- Required quantities and schedule for delivery to site.

Along with cost estimates and other required information, subcontractors would submit the following for Project Management Contractor (PMC) approval:

- Proposed haul method and equipment details.
- Haul cycle data.
- Haul road design, including surfacing, drainage, erosion control, traffic control, dust control plan and typical section.

OR

Conveyor loading and unloading equipment details, Missouri State Route 94 crossing design, and typical cross section for conveyor maintenance road and other related items mentioned above.

Technical Uncertainties

MVE Table 5.1.5-7 lists the uncertainties and possible design changes associated with the borrow haul method and Missouri State Route 94 crossing. If it is not possible to obtain permits to haul material over the land between the borrow source and the site, it will be necessary to haul the material using highway trucks on existing public roads. As shown in MVE

Table 5.1.5-8, several topics require additional study before final design of the haul method and haul route. Among these are: (1) geotechnical data for soils along proposed haul routes, (2) archaeological data for the area around potential haul routes, (3) locations of utilities in the area, (4) layout and processing operations at the borrow source, (5) Missouri Highway and Transportation Department (MHTD) concurrence, (6) easement for construction and operation of haul route from MDOC, (7) for small and minority businesses to bid more competitively, the haul road construction could be separate from the borrow operations, and (8) if MHTD decides to realign Missouri State Route 94 in conjunction with the borrow haul road construction, the Missouri State Route 94 overpass over an at-grade haul road could be a viable alternative.

5.1.5.2.7 **Site Roads Layout Design Criteria.** Design criteria associated with site roads layout are the minimum radius of horizontal curves, lane and shoulder widths, and maximum grade and vertical curve requirements.

Performance Requirements

The performance requirements of the layout design criteria are to provide:

1. A safe turning radius on horizontal curves.
2. Roadway widths for safety and efficiency.
3. Vertical curves where needed for a safe ride along site roads.

The following parameters were used for the evaluation of site roads design criteria:

- Vehicle and design live load: highway and off-highway construction equipment (maximum 50-ton dual axle).
- Maximum design speed: 25 mph.
- Actual posted speed: 20 mph.
- Design life: 10 years.
- Existing subgrade and pavement material California bearing ratio (CBR) values (see Figure 5.1.5-18).

Identification of Alternatives

MVE Table 5.1.5-9 lists the alternatives for maximum grade, vertical curve, and horizontal curve guidelines. The criteria used to evaluate maximum grade and vertical curve guidelines for site roads were tractive effort required on grades, ease of construction, cut and fill balancing, and minimizing cleanup demolition. Safety was the one criterion that was a given; no unsafe alternatives were considered.

Three alternatives are listed for minimum inside radius of horizontal curves. The inside radius is the distance from the inner edge of the inside lane to the center of the curve. Criteria used to evaluate minimum curve radii include the maximum possible speed of travel around the curve and the amount of material needed to construct the curve.

MVE Table 5.1.5-9 also lists the alternatives for lane and shoulder widths of both one-way single-lane and two-way double-lane site roads for use by highway vehicles. Safety, ease of traffic flow, and minimizing the amount of material used to construct site roads were all weighted heavily in the evaluation of roadbed widths.

Evaluation of Alternatives

MVE Table 5.1.5-9 lists the advantages and disadvantages of each alternative for maximum grade and vertical curve. The advantages of a low maximum grade for site roads are that vehicles can be driven faster on flat roads and that the tractive effort is very low for vehicles hauling loads up grades. However, building site roads with very low grades may require a lot of regrading and could make cut and fill balancing difficult. Because safety and site distance decrease with increasing tangent-grade changes on the road, it will be advantageous to construct vertical curves on some site roads. The disadvantages of constructing vertical curves over small tangent-grade changes are that the roads become more difficult and time-consuming to construct and construction vehicles may be driven too fast.

The advantage of requiring a high minimum inside radius for horizontal curves is that vehicles may safely travel at higher speeds around the curves. The disadvantage is that a large inside radius increases the length of the curve and, therefore, increases the amount of material and land used to construct the road. This adds to the necessary cleanup volume for demolition of site roads during the disposal facility closure phase.

Lane widths must accommodate the widest vehicle expected to travel on site roads. Large widths also promote speedy travel along site roads. However, large road widths may cause problems for site drainage, due to the relatively flat road surfaces. Larger widths also require more construction material, which must later be added to the disposal cell.

Selection of Preferred Alternative

The maximum allowable grade on site roads is 6%. A vertical curve is required if the tangent-grade change on a road exceeds 5%. The minimum inside curve radius of horizontal curves is 100 ft. One-way single-lane roads for highway vehicles are 12 ft wide with 0-ft to 2 ft shoulders on each side. Two-way double-lane roads for highway vehicles are 24 ft wide with 0-ft to 4-ft shoulders on each side. Two-way double-lane roads have wider shoulders than single-lane roads to allow more space for two lanes without a median. One-way single-lane site roads used by off-highway vehicles are 16 ft wide with 0-ft to 3-ft shoulders to accommodate the large vehicle widths. Two-way double-lane roads for off-highway vehicles are 32 ft wide with 0-ft to 4-ft shoulders. These limits are considered guidelines and, under specific conditions, can be modified by on-site or off-site engineering.

Details of the Preferred Alternative

The limits on vertical grade change and tangent-grade change without a vertical curve were chosen to provide a safe ride at moderate speeds and low additional tractive effort for hauling equipment on grades. Cut and fill balancing was also considered in selecting these two limits. A 100-ft radius allows vehicles to travel about 25 mph on curves. For safety, the inside radius allows speeds slightly higher than the actual posted speed at the site. The lane and shoulder widths will provide safe and efficient travel, with minimal amount of material for clean-up demolition. Lane and shoulder widths for off-highway vehicles will accommodate the widest vehicles expected to travel on site roads.

Technical Uncertainties

MVE Table 5.1.5-10 lists the uncertainties associated with horizontal curves and roadbed widths. In areas where construction activity limits the length of horizontal curves, a lower radius may be used if a means of reducing vehicle speed, such as a yield or stop sign, is

provided before the curves. MVE Table 5.1.5-11 shows that the areas where construction activity may limit the lengths of horizontal curves are unknown.

For lane and shoulder widths, MVE Table 5.1.5-10 shows that, where two-way traffic volumes are low, a two-way double-lane road may be reduced to a single-lane road with turnouts to accommodate two-way traffic. This may occur on site roads for both off-highway and highway vehicles. Estimates of the anticipated one- and two-way traffic volumes on site roads are needed to resolve this uncertainty.

In areas where the work required to level a road to a 6% grade would significantly hinder other operations, slopes up to 10% will be allowed for reasonably short distances. A 10% slope will be permitted on ramps, such as those used to place waste in the disposal cell. If a grade change in an area may pose a hazard to workers due to poor visibility or any other problem associated with a change in grade, a vertical curve will be required where the tangent-grade change exceeds 1%. An example of conditions where poor visibility could be hazardous is the intersection of two dirty roads. Every effort should be made to prevent accidents that involve vehicles transporting contaminated materials. Because night shift work may be performed, MVE Table 5.1.5-11 indicates that shift work is a concern for vertical curve requirements due to the poor nighttime visibility.

5.1.5.3 Site Roadway Preparation. Section 6.1.5.3 describes the design criteria and operations required for the preparation of the roadway subgrade. In addition, the design criteria associated with the roadway preparation are the roadway cross slopes and side slopes.

Identification of Alternatives

MVE Table 5.1.5-12, Results of Modified Value Engineering: Site Roadway Preparation, lists the alternatives for roadbed cross slopes for both one-way single-lane and two-way double-lane roads. The criteria used to evaluate the alternatives in both cases were ease of steering, minimizing the amount of material to be added to the disposal cell, road safety, drainage, and public acceptance.

The table also lists three alternatives and the criteria used to evaluate site roads side slopes. Among the most heavily weighted criteria used in evaluating side slope alternatives were

maintainability, slope stability, minimizing the amount of material for cleanup demolition, and drainage.

Evaluation of Alternatives

The choice of a suitable roadbed cross slope for each road type essentially involved a trade-off between drainage and the amount of material needed to construct the crown or cross slope. A steep crown or cross slope provides good drainage, but requires a large buildup of material in the middle or on one side of the road. In either case, curves should slope from outside to inside to provide a banked condition. MVE Table 5.1.5-12 lists the advantages and disadvantages associated with each alternative.

For the side slopes, drainage was again balanced with the amount of material required to construct the slope. However, in the case of side slopes, maintainability was an added consideration. MVE Table 5.1.5-12 lists ease of mowing as an advantage of the milder slope alternatives.

Selection of Preferred Alternative

Both single- and double-lane roads will have a crown slope of minimum 2% and maximum 6%. This section was chosen to provide good steering and adequate drainage, and because of the small amount of material needed to build a crown slope (compared to a cross slope). Site road side slopes will be maximum 3H:1V in cut or fill. The 3:1 slope was selected to provide a slope that can be mowed, while limiting the amount of material required in fill slopes. This stable slope will also provide adequate drainage away from site roads.

Details of the Preferred Alternative

Figure 5.1.5-19 shows typical sections of both one-way single-lane and two-way double-lane roads for highway vehicles. Figure 5.1.5-20 shows typical sections of one- and two-way roads for off-highway vehicles. Side slopes in fill begin at the top of the surface layer and end where the fill slope meets existing ground or the top of a drainage ditch. Side slopes in the cut end at the top of the road surface layer. Drainage ditch details are discussed in Section 5.1.6, Site Drainage.

The top layer of the site road subgrade will be excavated or scarified and recompacted to 95% of the modified Proctor (AASHTO T134) maximum dry density. The minimum compacted thickness of the subbase shall be 6 in. The recompaction of subgrade is necessary to limit rutting under the action of heavy construction equipment. No brush, roots, stumps, sod, or other organic or unsuitable materials shall be permitted in the subbase. Figures 5.1.5-19 and 5.1.5-20 show the 6 in. of recompacted subgrade in each of the typical road sections. These figures also show the alternative pavement sections that were considered. The selection of pavement sections is discussed in Section 5.1.5.4, Surfacing.

Technical Uncertainties

MVE Table 5.1.5-13 indicates that a possible design change to the roadway cross section is the use of a 2% to 6% cross slope (instead of a crown slope) in areas where drainage specifications require the direction of runoff to one side of the road. This could occur where a contaminated road borders a clean area or where a site road borders a contaminated area. In the first case, the dirty road could be sloped to drain away from the clean area. In the latter, the road could be sloped to drain into the contaminated area, so that contaminated water does not cross the road and enter a clean area. MVE Table 5.1.5-14 lists the data collection activities necessary to resolve the uncertainty in roadway cross slopes. Typical road sections with a 2% to 6% cross slope are also illustrated in Figures 5.1.5-19 and 5.1.5-20.

While a preferred maximum of 3H:1V is desirable for all site roads side slopes, in some areas construction activity or other constraints may limit the width of the side slopes. These areas will require special attention and will be evaluated on a case-by-case basis. The potential for this problem is high along the west boundary of the disposal cell area, where the CFD toe approaches Raffinate Pit 3, leaving little room for a site road between the two. In cases where spatial constraints limit the width of side slopes, maximum 2H:1V side slopes will be permitted in cut or fill, provided no data collection activities are required.

5.1.5.4 Surfacing. Various types of site road surfaces could be used for transporting waste and new construction materials. The types of road surfaces considered suitable are:

- Portland cement concrete
- Asphalt concrete

- Dirt (compacted subgrade material)
- Gravel
- Oil and rock (chip seal)

As in the case of site roads layout and roadway preparation design criteria, the MVE process was used to evaluate surfacing alternatives. The MVE process was also used to evaluate the thickness and compaction requirements of the selected surface material.

Identification of Alternatives

The criteria used to select the preferred surface are listed in MVE Table 5.1.5-15. This table also lists the criteria used to select an appropriate range of thicknesses and the required degree of compaction for a gravel surface. Thicknesses of materials in the alternative pavement sections were estimated using three types of vehicle loads. The first was the American Association of State Highway and Transportation Officials (AASHTO) HS-20 loading, for site roads on which only highway vehicles will be permitted. As stated in Section 5.1.5.2.6, Site Roads Layout Design Criteria, the site roads design load is a maximum 50-ton dual axle. This is the load applied by a 40-ton-capacity haul truck or a common scraper, which are the largest and heaviest vehicles expected on the site. Figure 5.1.5-18 shows the minimum CBR of a material needed to support these load types at a given depth (design thickness) below the pavement surface. Figure 5.1.5-18 also shows the CBR curves for a 58-ton-capacity truck and a heavy (180-ton) scraper, which could be used on the site.

In each of the pavement section alternatives shown in Figures 5.1.5-19 and 5.1.5-20, the base course is compacted gravel, and the subbase is compacted subgrade material. MVE Table 5.1.5-16 lists the CBR values used for in situ subgrade soil, compacted subgrade soil, and compacted gravel. The CBR values of Portland cement concrete, asphalt concrete, and oil/rock material will be adequate to support the loads at the surface, so their CBR values are not included in Table 5.1.5-16 and Figure 5.1.5-18. Table 5.1.5-16 summarizes the recommended pavement thicknesses for each of the three load curves in Figure 5.1.5-18. These are the pavement thicknesses illustrated in Figures 5.1.5-19 and 5.1.5-20.

MVE Table 5.1.5-15 shows that the most heavily weighted criteria for the selection of a surface material were worker safety, dust control, and public perception. Dust control is of major importance because of the potential hazard of contaminated dust blowing around or off

the site. For this reason, no dust can be permitted on site roads. Public perception is important, because the site is near a large community; the public must consider the site roads safe and dust free. Impact on cell construction was also weighted heavily in the evaluations. The construction of site roads should not impede construction of the disposal facility.

Evaluation of Alternatives

Gravel, asphalt, Portland cement concrete, and oil and rock surfaces were considered very safe. A dirt surface was considered slightly inferior because of the potential for erosion and rutting. In dust control, asphalt concrete, Portland cement concrete, and oil and rock surfaces were rated excellent. Gravel provides good dust control, whereas a dirt surface provides poor dust control. It was also assumed that the public would not have a good perception of dirt roads.

The major disadvantages of a Portland cement concrete and asphalt concrete surfaces are the lack of flexibility and the permanent characteristics these surfaces have, which might interfere with cell construction. Dirt and gravel surfaces are the easiest to construct and have very little impact on cell construction.

With regard to the other criteria listed in MVE Table 5.1.5-15, the oil and rock surface was considered inferior to gravel, Portland cement concrete, and asphalt cement because it may require major maintenance after heavy equipment (especially tracked equipment) passes over the surface. Although these surfaces exhibit excellent performance, asphalt and Portland cement concrete surfaces will require major maintenance after being subjected to heavy traffic loading for some time. Another disadvantage associated with oil and rock and asphalt concrete surfaces is that petroleum-based binders increase the amount of the contaminated soil on site.

For gravel surface thickness and compaction requirements, the benefits of several thicknesses were weighted against the difficulty in obtaining the degree of compaction required to support the design vehicle loading.

Selection of Preferred Alternative

Based on an evaluation of the aforementioned road surfaces, gravel is the preferred surface. A gravel surface will require periodic minor maintenance but is not likely to require

major repair. Compared to asphalt concrete or Portland cement concrete, gravel roads are easier to construct, and gravel contains no contaminants and would have very little effect on cell construction. A gravel surface will also control dust and perform better than a dirt surface. However, in areas of highly traveled roads, asphalt can be used to minimize water truck activity and maintenance work.

Details of the Preferred Alternative

Figures 5.1.5-19 and 5.1.5-20 show pavement sections with gravel, oil and rock, asphalt concrete, and Portland cement concrete surfaces. For highway vehicles, site roads surface course will be 6 in. thick, and the base course will be 18 in. thick. For off-highway vehicles, site roads surface course will be 8 in. thick, and the base course will be 22 in. thick. The type and gradation of the surfacing material will be determined during Title II design.

The gravel surface and base course will be compacted to 95% of the modified Proctor test. This degree of compaction was chosen to provide a surface with good stability, durability, and strength.

Technical Uncertainties

MVE Table 5.1.5-17 and Table 5.1.5-18 list the technical uncertainties associated with the gravel surface. The probability that the gravel surface will not adequately support the vehicle loads is very low. Therefore, the probability that an asphalt surface will be used on site roads is very low. However, some problems with rutting or excessive maintenance may occur, due to the quality of subgrade material at the site or excessive traffic. If the gravel surface exhibits excessive rutting, then asphalt should be considered. However, it is imperative that the gravel and subgrade material be compacted to specification. Otherwise, rutting will occur regardless of the surface material quality.

5.1.5.5 Summary of Design Criteria and Specifications. Evaluation of the various alternatives in the previous sections indicates that the functional and performance requirements for site roads listed in Section 5.1.5 are best met by the design criteria presented in Table 5.1.5-19. Table 5.1.5-20 provides an outline of the specifications related to the site roads.

5.1.5.6 Site Roads System Analysis. To meet the functional and performance requirements, design of the site roads must be incorporated into a coordinated system. The transportation plan presented in this section provides safe and efficient travel during each disposal cell construction phase. The design criteria also include alternatives for special conditions, such as spatial constraints or hazardous conditions along site roads. In general, the emphasis of the site road system was to adjust the design to meet the needs of the various site activities.

Other remedial action activities which affect the site road design are in turn impacted by road design and layout. The layout of site roads also affects site drainage. The site roads system must be coordinated with overall site drainage design to prevent contaminated water from draining into clean areas. As noted in Section 5.1.5.3, roadbeds may have cross slopes rather than crown slopes where drainage specifications require drainage to one side of the road. Dirty site roads which border contaminated areas should have a cross slope which directs runoff toward the contaminated area. Designated clean site roads which border uncontaminated areas should slope to drain toward the clean areas. The transportation plan will have a significant affect on haul cycle frequency and waste removal schedule. Therefore, the construction of site roads must adhere to schedules specified in the system -wide plan.

Performance Requirements

The performance requirements of the components of the site roads system design are to:

- Control dust on site roads.
- Prevent vehicles transporting contaminated materials and vehicles entering contaminated areas from traveling on clean site roads.

Identification of Alternatives

Petroleum-based dust suppressants, cementitious binders, periodic resurfacing of roads, and spraying roads with water or other surfactants were considered as possible methods to control dust on site roads. MVE Table 5.1.5-21 lists the criteria used to evaluate each alternative for dust control.

Visibility, resistance to wind and weather, and ease of construction were among the heavily weighted criteria used to evaluate methods of demarcating clean site roads. The alternatives listed in MVE Table 5.1.5-21 include markers made of various materials and fence-like structures.

Evaluation of Alternatives

MVE Table 5.1.5-21 lists the advantages and disadvantages of each alternative for both the dust control method and the demarcation of clean site roads. Using water to control dust is effective for only a short period of time, depending on the ambient temperature and humidity. However, the use of chemicals or petroleum-based dust suppressants is undesirable, because it adds to the volume of contaminated material. Resurfacing gravel roads would require a great deal of effort for only a slight benefit in terms of dust control. The effectiveness of the method of demarcating clean site roads depends highly on the visibility of the markers used. Mobility of the markers was also considered, due to the changing layout of site roads during various phases of disposal cell construction. Advantages associated with some of the more permanent methods of marking roads are that they are generally more resistant to the elements. The disadvantage is that sturdier markers are more difficult to install and to remove or re-use.

Selection of Preferred Alternative

The preferred method of dust control is to use separate water trucks for clean and dirty areas. Clean roads will be demarcated by wooden stakes with colored flags or strips of cloth fastened to them.

Details of the Preferred Alternative

Water trucks were chosen for dust control because of the abundance of water in the area, and because water trucks are currently used for dust control on the site and meet the objective of minimizing additional contamination. The effectiveness of this dust control method may be improved by using a larger-sized aggregate for the gravel road surface so that dust can fall into the gravel interstices. Also, nontoxic, nonflammable, biodegradable dust suppressants may be added to the water sprayed by trucks to improve dust control.

A designated clean water truck will travel only on designated clean site roads, and a designated dirty water truck will travel only on dirty roads. As stated in Section 5.1.5.2, a clean road will be provided around the inner perimeter of the site so that clean water trucks may travel around site without encountering dirty roads. The water supply for designated dirty water trucks will be a water truck fill tank located in a contaminated area south of the SWTP. Designated clean water trucks, likewise, will obtain water from a water truck fill tank located in an uncontaminated area near the west boundary of the TSA. Water for clean water trucks could also be supplied by pumping treated water out of the effluent ponds at the SWTP. Fire hydrants will not be used to fill water trucks.

The wooden stakes used to demarcate clean site roads will be driven into the shoulders of clean roads and will be connected by string or streamers. The line of wooden stakes and flags was chosen because of its good visibility and its fence- or barrier-like appearance. The wooden stake fence is also easy to assemble and disassemble, is easy to move, and is resistant to wind and weather.

Technical Uncertainties

MVE Table 5.1.5-22 lists the technical uncertainties associated with the methods of dust control and demarcation of clean site roads. For demarcation of clean roads, Table 5.1.5-21 shows that rubber highway lane markers and colored erosion control fencing are viable alternatives to the wood and cloth strip fence. These methods may be preferred for the site. MVE Table 5.1.5-23 indicates that no data collection activities are needed for uncertainties relating to either dust control or clean road demarcation.

Performance of Component

The use of separate clean and dirty water trucks on site roads will be sufficient to control dust, while avoiding the use of contaminants on the site. The high visibility and fence- or barrier-like appearance of strips of cloth on wooden stakes connected with string or streamers is expected to keep contaminated vehicles from driving onto designated clean site roads.

5.1.6 Site Drainage

5.1.6.1 General. Site drainage refers to control and collection of rainfall within the Weldon Spring Chemical Plant site and conveyance of the collected rainfall to an off-site discharge location. In addition to standard drainage control structures, features unique to the chemical plant site drainage are the facilities necessary to segregate runoff from contaminated and noncontaminated areas. Storage facilities for temporary containment of contaminated runoff are also needed.

Figure 5.1.6-1 shows surface water features and drainages at the chemical plant area. A surface water divide that separates drainage of the Mississippi and Missouri rivers bisects the site. Unnamed tributaries from the site drain into Schote Creek at the northern portion of the site. The Southeast Drainage carries runoff from the southern portion of the site to the Missouri River. All drainage tributaries on the site are ephemeral or intermittent streams. During site remediation, existing drainage patterns and areas will be preserved to the greatest extent practical.

Development of the conceptual site drainage plan involves consideration of several site drainage factors. These factors include delineation of existing drainage areas, modification of the existing drainage system, control of runoff during the disposal facility construction phases, control of runoff during waste placement, establishment of permanent drainage control structures, and operational uncertainties. These factors are discussed in subsequent sections. Preferred alternatives were selected based on the methodology outlined in Section 3.

The disposal facility will be designed to resist gullying or headward erosion during a PMP (probable maximum precipitation) event after site closure by inclusion of a rock apron around the toe of the facility (refer to Section 5.2.7, Waste Containment System). The rock apron will minimize requirements for riprap stabilization in permanent drainage channels, and will also serve as an energy dissipator for runoff from 5:1 (H:V) CFD side slopes.

The site drainage plan will comply with all requirements for proper control and handling of site waters described in the *Surface Water Management Plan* (Ref. 36). Some of the design criteria for drainage control structures will be derived from the *WSSRAP Chemical Plant Surface Water and Erosion Control Report* (Ref. 47). Proposed sediment detention basins and existing watersheds are described in (Ref. 47) and are shown on Figure 5.1.6-2. In developing the site

drainage plan, it was assumed these sediment detention basins would be constructed prior to any remediation or disposal facility construction. The sediment detention basins will be designed as flow-through structures rather than as temporary containment facilities.

5.1.6.2 Functional Requirements. The site drainage system will ensure that positive drainage occurs from site roads and work areas to prevent the occurrence of standing water. Drainage control structures will isolate contaminated areas from noncontaminated areas to prevent cross-contamination of runoff and run-on water. Suitable means, such as impoundments or temporary detention facilities, will prevent the release of contaminated water from the site.

5.1.6.3 Performance Requirements. The flow velocities of the drainage channels and drainage control structures within the storm drainage system will be designed to ensure a low erosion potential and will require minimal channel stabilization. Overtopping of roads by design storms will be prevented by providing adequate culvert sizes in ditches passing under roads. Adequate check structures and stabilization measures will be employed to minimize suspended solids. Except for transport of contaminated runoff, gravity drainage should be used exclusively. Existing drainage structures and features will be used, where feasible, to minimize construction requirements, which will include the use of existing retention basins and the use of topographic depressions for new retention basins.

5.1.6.4 Storm Drainage Parameters. *Supporting Study 27, Design Storm Criteria Assessment* (Ref. 42), presents information regarding selection of design storms for the Weldon Spring site. This study presents rainfall data for various durations and return periods of storms in the form of depths and intensity values.

The return period or frequency is the time period over which the storm would be expected to occur once. The reciprocal of the return period is the probability of the storm occurring during a one-year period. For instance, a 100-year storm would have a 1% chance of occurring in any one year and would be expected to occur once in a 100-year period. Duration is the length that the storm lasts: a one-hour storm or a 24-hour storm, for example.

Selection of a storm return period or frequency should consider the potential risk of failure of a design and the economic and social costs that may be incurred if the design rainfall

is exceeded. The return period is related to the risk of failure and the design life by the formula:

$$T = 1/[1-(1 - R)^{1/n}]$$

where

T = storm return period (years)
R = potential risk associated with a failure of the system (percent)
n = design life of the facility in years

Storm durations and frequencies specified for some activities by site design manuals and government regulations are also given in *Supporting Study 27* (Ref. 42). These storm durations and frequencies have been used for the site drainage task, since economic and risk analyses are too detailed for the purposes of conceptual design. Suggested precipitation values, durations, and storm return periods for use with various activities in the Conceptual Design Report (CDR) at the Weldon Spring site are listed in Table 5.1.6-1. During final design, storm return periods will be determined using a risk analysis approach.

Runoff curve numbers (RCNs) and runoff coefficients necessary to characterize surface conditions are listed in *Supporting Study 27* (Ref. 42). Hydrologic soil groups present at the site are also delineated in *Supporting Study 27* (Ref. 42). These values were used in the site drainage task to characterize watersheds.

5.1.6.5 Existing Storm Drainage System. The existing storm drainage system was evaluated in the *Chemical Plant Surface Water and Erosion Control Report* (Ref. 47). Five separate watersheds, shown on Figure 5.1.6-2, were delineated. Discharges and runoff volumes for three separate storms for each of the five areas are shown in Table 5.1.6-2. Runoff curve numbers for each watershed are also listed in this table.

The existing storm sewer network within the chemical plant area will remain in place during building dismantlement. Existing catch basins will be surrounded with straw bale filters as described in the *WSSRAP Chemical Plant Surface Water and Erosion Control Report* (Ref. 47) to minimize the possibility of sediment entering the storm sewer system during dismantlement operations. After contaminated soil and sediment removal, the existing storm

sewer's underground piping will be extracted as chemical plant building foundations are removed (Section 5.1.2). Surface drainage features will replace the existing underground storm sewer network.

Two prominent features of the existing storm drainage system are the Ash Pond isolation dike (APID) detention facility and Frog Pond. The existing APID detention facility, shown on Figure 5.1.6-2, will remain in place for most of the project's duration but may be upgraded. The APID will adequately contain the runoff from storms up to a 25-year, 24-hour event for the current drainage situation, as indicated in Table 5.1.6-3. The recommended design storm for sizing retention ponds in the disposal cell/chemical plant area is a 25-year, 24-hour storm (Table 5.1.6-1). During disposal cell construction and remediation, alteration of drainage areas and hydrologic conditions will result in increased runoff volume (see Section 5.1.4.4.4). Therefore, expansion of the APID will be required to contain potentially contaminated runoff.

Contaminated soil within Frog Pond (Figure 5.1.6-2) will be remediated during the same time period as foundation removal, as discussed in Section 5.1.2.2.8, Removal Sequence and Schedule. Table 5.1.6-3 indicates that, although Frog Pond's storage capacity is minimal (a two-year, 24-hour event is not contained), the emergency spillway of the facility attenuates peak storm water flows. After remediation, the pond should be kept in place and the emergency spillway upgraded so the pond can continue to function as a flow attenuation structure. Keeping the pond in place will help prevent erosion of the channel bed downstream of the pond.

5.1.6.6 Storm Drainage System Modifications. Modifications to the storm drainage system will involve construction of surface drainage features to redirect and convey storm water runoff that previously exited the site through the original underground storm sewer network. Existing drainage channels will be modified to incorporate new topographic features such as the disposal cell clean-fill dike, the removal of the raffinate pits, and the regraded chemical plant area after contaminated soil excavation. Configuration of the modified drainage system will be dependent upon how potentially contaminated runoff is managed. Results of MVE sessions to determine the best alternative for managing potentially contaminated runoff are discussed below.

5.1.6.6.1 Identification of Alternatives. The various alternatives for handling potentially contaminated storm runoff, or runoff that comes in contact with waste, are described below:

- Contain none of the potentially contaminated storm water runoff (no action).

- Contain all of the potentially contaminated storm water runoff. This includes runoff from uncovered material in the disposal cell, from contaminated soil/sediment excavations, from contaminated soil stockpiles, and from "dirty" haul roads.

- Contain potentially contaminated runoff from uncovered material in the disposal cell only.

- Contain potentially contaminated runoff from uncovered material in the disposal cell and contaminated soil/sediment excavations.

- Contain potentially contaminated storm water runoff from uncovered material in the disposal cell, contaminated soil/sediment excavation areas, and contaminated soil stockpiles.

5.1.6.6.2 Evaluation of Alternatives. A review of MVE Table 5.1.6-4 shows that segregating all potentially contaminated runoff from noncontaminated runoff is the most viable alternative (second alternative in list) for preventing cross-contamination and off-site release of contaminated storm water runoff. Other options would be less costly and require less construction, but may result in contamination levels in runoff leaving the site that are higher than allowed by National Pollutant Discharge Elimination System (NPDES) permit limits. Options other than the containment of all potentially contaminated runoff could also result in cross-contamination, which would increase contaminated waste volumes.

5.1.6.6.3 Selection of Preferred Alternative. The preferred alternative is to segregate and contain all the potentially contaminated storm water runoff that is generated on the site. Runoff from the following areas will require containment:

- The disposal cell during waste placement.
- Areas where contaminated soil and sediments are being excavated.
- Dirty haul roads.
- Contaminated soil stockpiles.
- Waste treatment plant.

5.1.6.6.4 Details of Preferred Alternative. Separation of storm water runoff within contaminated and noncontaminated areas will minimize the possibility of cross-contaminating clean areas and of transporting contaminated material off site through drainageways. Separating contaminated from noncontaminated runoff will require modifications to current drainage facilities for transporting and storing this runoff. The following description outlines how this will be accomplished. More detailed descriptions of storm water control during construction and operation of the disposal facility follow in Section 5.1.6.6.6.

Prior to construction of the disposal facility, contaminated soil and sediment beneath the cell footprint will be excavated and the material stored in the Ash Pond spoils pile area (Figure 5.1.6-2). Most of the excavations will be small, ranging from 0.1 acres to 2.5 acres. Storm water runoff occurring in these excavations will be contained in small sumps prior to being transported to the raffinate pits via a pumper truck (Ref. 48 and Ref. 49). The small sumps will be low spots in excavations or bermed areas. Contaminated runoff from soil and sediment excavations outside the disposal cell footprint will be contained and transported in the same manner.

After waste placement within the disposal facility begins, runoff from the uncovered waste will be transported via ditches and pipelines to retention ponds. This will require designating retention ponds to contain potentially contaminated runoff. Retention ponds are structures with an outlet device that can temporarily contain runoff water. For existing conditions prior to cell construction, the APID (Figure 5.1.6-2) has sufficient capacity to contain runoff from a 25-year, 24-hour storm for the existing site drainage pattern (see below). This capacity will not contain runoff from uncovered waste within Phases I and II of the disposal facility, as shown in the table below. Some enlargement of the APID facility will be required. Since the slope of the disposal facility will not allow runoff from Phase III waste to gravity drain to the APID, an additional retention pond will be needed to contain runoff during this phase. The required capacity for this pond is shown in table below. Runoff volumes for wastes in all three phases of the disposal facility were calculated assuming that VIT materials were covered with a layer of clay, resulting in infiltration characteristics identical to those of the CSS materials.

Runoff Volume (acre-feet) For 25-Year, 24-Hour Storm Within Disposal Facility

Disposal Facility Construction Phase	I	II	III
Estimated Runoff Volume (acre-feet)	11.4	9.2	4.4

Runoff from dirty haul roads will be channeled through ditches that are separate from the ditches carrying clean runoff. Figure 5.1.6-3 illustrates contaminated and noncontaminated runoff control structures for dirty roads. Existing drainage patterns will require slight modification to allow this water to be channelled into the APID and into the new retention pond required for Phase III of the disposal facility. Runoff from clean haul roads will be conveyed to sediment detention basins located around the perimeter of the site, as shown on Figure 5.1.6-2.

Storm water runoff from contaminated soil stockpiles in the vicinity of Ash Pond will be conveyed into Ash Pond for containment and possible treatment. As contaminated soil is placed into the Ash Pond spoils pile, provisions will be required for maintaining channels to allow runoff from stockpiles outside Ash Pond into Ash Pond.

5.1.6.6.5 Technical Uncertainties. A technical uncertainty associated with the modified storm drainage system is that the quality of water discharged off-site may not meet NPDES permit requirements of 1.0 ml/l/hour total settleable solids limit. The probability of this occurring is low since all runoff from contaminated waste will be contained within retention ponds and tested for contamination. Contaminated runoff will be transferred and treated in the site water treatment plant. Runoff from noncontaminated areas will also be routed through sediment detention basins designed to remove suspended solids to levels below NPDES permit limits. Best management practices will also be used as specified in the *WSSRAP Chemical Plant Surface Water and Erosion Control Report* (Ref. 47) for erosion and sediment control at disturbed areas. The ongoing NPDES permit monitoring process will provide data to verify that water quality objectives are being met.

5.1.6.6.6 Alterations in Storm Drainage System During Disposal Facility Construction. Figures 5.1.6-4 through 5.1.6-8 show site drainages during five sequences of the disposal facility construction, operation, and closure period. Each sequence figure roughly represents the appearance of the site at the end of each year, beginning with the year after construction of the disposal facility begins and ending with waste placement during Phase III.

The locations of retention ponds for containing potentially contaminated runoff are identified in these figures as Ponds 1, 2, and 3. Pond 1 will be constructed in an existing topographic depression north of the disposal facility. Figure 5.1.6-9 shows the details of Pond 1. Pond 2 will be constructed within the Ash Pond spoils area. Radiation contamination levels in the discharge from Ash Pond must be less than 600 pCi/l, annualized average, or be treated in the site water treatment plant (Ref. 5). Because of the treatment requirements, the outlet structure for Ash Pond must be modified to allow containment of runoff for testing prior to release. Pond 3 is the APID. The APID is equipped with a controlled outlet structure. Contaminated runoff in the MSA and the TSA is contained within retention ponds located in those facilities.

Table 5.1.6-5 shows peak discharges at outlets of drainage areas during each construction sequence shown on Figures 5.1.6-4 through 5.1.6-8. Discharges calculated using the TR-55 method (Ref. 108) are listed. The TR-55 method is a simplified method for estimating peak discharges and runoff volumes in small watersheds. Peak discharges throughout the five sequencing scenarios at Sedimentation Basins 1, 4, and 5 are listed in Table 5.1.6-6. Review of the table shows that peak discharge for Basin 4 increases roughly 240% during construction Sequence 5. This increase occurs because, after removal of stockpiled soil within Ash Pond spoils area, it is assumed that runoff is no longer held within the pond, and uncontrolled discharge occurs through the outlet works. During final design, Sedimentation Basin 4 should be designed to attenuate this peak flow. Peak discharges in the other sediment basins will not increase dramatically during the cell construction sequences, because hydraulic grades and soil cover complexes will not be altered significantly.

The major conveyance channels, ditches, and swales should be designed to accommodate the peak discharge rates listed for the appropriate drainage area. Major drainage channels are depicted in Figures 5.1.6-4 through 5.1.6-8. Section 5.1.6.8 lists the criteria for determining whether a lining is required. Since most of these channels are temporary structures, linings should be limited to erosion control mats in steep channels where stabilization is required. Figure 5.1.6-3 and Figures 5.1.6-9 through 5.1.6-11 show construction of typical channel cross sections.

During waste placement within the disposal cell, water will be conveyed from the in-place waste area to retention ponds using pipelines, as shown in Figures 5.1.6-4 through 5.1.6-8. Gravity flow will be possible during waste placement in Phase I. Construction of the clean fill

dike in Phases II and III may necessitate the use of pumps to transfer potentially contaminated runoff from the in-place waste to Retention Pond 2 or 3. To avoid the use of pumps, the final design process should consider use of gravity drainage to transfer runoff from waste in the disposal facility to the retention ponds.

5.1.6.7 Permanent Drainage Control Requirements. Permanent drainage control structures will be required after the disposal facility has been completed and the site is restored to native conditions. Sedimentation basins and retention ponds will have to be removed since an ongoing maintenance program will not be in place to repair outlet works or remove sediment and debris. Available alternatives for drainage control to replace the temporary facilities are mainly limited to drainage channels with minor hydraulic structures. Because of the lack of options, no alternatives were evaluated. Standard engineering practice will be used to determine the type of permanent lining that will be placed in drainage channels, and to determine the requirements of any hydraulic grade control structures.

5.1.6.7.1 Functional Requirements. Permanent drainage control should provide surface drainage off site after final grading and revegetation is completed. Permanent drainage control structures should intercept and convey runoff to existing off-site drainages at non-erosive velocities. To prevent scour downstream, peak discharges in off-site drainages should not be increased over existing conditions.

5.1.6.7.2 Performance Requirements. Permanent drainage control structures must perform adequately without maintenance after site closure. Drainage control structures should minimize irregularities in slope, grade, and roughness so that runoff flowing off site does not promote erosion. Conveyance channels should be adequately stable to resist degradation during major flood events.

Permanent Drainage Control Channels

Figures 5.1.6-12 and 5.1.6-13 show the locations of permanent drainage channels and contributing drainages to these channels with the CSS and VIT cells in place. Final site grading was adapted from *Supporting Study 16, Disposal Facilities Grading Plan* (Ref. 50). The two largest drainage areas encompass most of the disposal facility cover area and Ash Pond and Frog Pond. These drainages cover about 70 acres each. Peak discharges calculated using the TR-55 method (Ref. 108) for the 100-year, 24-hour storms will be over 200 cu ft/second in each of the

drainages. Riprap channel stabilization will be required in certain channel reaches as shown in Figures 5.1.6-12 and 5.1.6-13, to ensure protection against headward erosion of channels that would endanger the disposal cell cover. Installing a riprap apron around the toe of the disposal facility would negate the requirement for riprap in drainage channels.

The other drainage channels will have smaller contributing drainages and lower peak discharge rates. These channels can be lined with vegetation to maintain stability. These channel slopes should be gradual to prevent high flow velocities that could produce high shear forces on the vegetation. However, slopes should be steep enough to prevent water from ponding and submerging vegetation.

Permanent drainage channels should be either trapezoidal or triangular, depending on peak flows. Peak flows should be calculated at several points in each channel reach during final design as final site grading plans are developed. Channel design criteria are listed in Section 5.1.6.8.

Grade Control Structures

Figure 5.1.6-12 also shows potential locations for grade control structures. Channel reaches in these locations have steep slopes, and degradation of the channel bottom may occur. Grade control structures can stabilize channel slopes without requiring excavation to achieve a milder slope. Simple grade control structures are constructed by placing large riprap within channel reaches with steep slopes. A riprap apron is placed downstream to prevent scouring. A riprap-lined plunge pool can also be located at the toe of the structure. Hydraulic analysis of channel reaches with abrupt changes in slope should be performed during final design to determine whether grade control structures are necessary. Section 5.1.6.6 lists the design criteria for drop structures. Figure 5.1.6-11 shows a rock grade control structure.

Figures 5.1.6-12 and 5.1.6-13 show the locations where headcutting of stream beds may occur in drainages at the toe of the disposal facility. The toe of the disposal facility side slopes may be endangered by headcutting. Measures such as riprapping the channels or extending the apron at the toe of the disposal facility should be considered in final design.

5.1.6.8 Design Criteria and Specifications. General design criteria for site drainage control structures are listed in the *WSSRAP Chemical Plant Surface Water and Erosion*

Control Report (Ref. 47). Expanded design criteria and applicable codes and standards are listed below. An outline of specifications is presented in Table 5.1.6-7. These specifications will be developed in Title II design.

Open Channel Design

See Figure 5.1.6-9 through 5.1.6-11 for detailed drawings.

- Channel lining:
  - Riprap for channel velocities between 5 and 12 fps.
  - Vegetation (grass) for channel velocities less than 5 fps.
- Minimum channel side slopes:
  - 1.5:1 (H:V) for roadside ditches.
  - 2:1 (H:V) for drainage channels (permanent and temporary).
- Bottom width:
  - 0 ft for roadside ditches (triangular).
  - 2-ft minimum for permanent and temporary drainage channels; if greater than 4 ft, slope the bottom at 5% toward the ditch center. The "V" shape will deter the formation of a meandering low flow bottom.
- Design discharge:
  - 25-year, 6-hour storm for roadside ditches and temporary drainage channels, unless risk of failure as determined by procedures in *Design Storm Criteria Assessment* (Ref. 42) dictates the use of a larger event.
  - 100-year, 24-hour storm event for permanent drainage channels.

- Freeboard:

  - 0.5 ft for roadside ditches and temporary drainage channels.
  - 1.0 ft for permanent drainage channels.

- Channel slope: 0.5% minimum to prevent ponding and 12.5% maximum to prevent scouring and erosion.

Retention Ponds

Design capacity should be the 25-year, 24-hour storm. An emergency outlet should be provided and sized for the 25-year, 6-hour storm. Lining requirements will be determined through negotiations with the Missouri Department of Natural Resources (MDNR).

Sedimentation Basins

Sedimentation basin design should ensure NPDES effluent standards are maintained. Ponds will be constructed and lined in accordance with 10 CSR 20-8.200.

Culverts

Culverts should be designed to pass the 25-year, 6-hour storm without any static head and the 100-year, 24-hour storm without overtopping roads or structures. Channel erosion protection in the form of riprap or erosion mats should be provided for at least two culvert diameters upstream and four diameters downstream.

Riprap

- $D_{max} = 2 \times D_{50}$.
- $D_{10} = (0.2 \text{ to } 0.3)\ D_{50}$.
- Thickness of riprap is $2 \times D_{50}$.

Where:

D_{50}	=	Theoretical spherical diameter of average stone size.
D_{max}	=	Theoretical spherical diameter of largest stone size.
D_{10}	=	Theoretical spherical diameter of the stone size for which 10% of the material is smaller

- When riprap is used in a channel transition, riprap should be placed a distance five times the normal downstream channel depth both upstream and downstream of the transition, with a minimum length of 15 ft.

Riprap should be placed by hand or by dumping from trucks and should conform to the shape of the channel. Plastic filter cloths or granular filters should also be provided to inhibit migration of native soils from the channel bottom into the stream flow. Granular filters should be used for all riprapped permanent drainage channels, because plastic filter cloths will degrade over time.

Rock Grade Control Structures

- Maximum drop height of 3 ft. Use multiple structures if drop height is greater than 3 ft with spacing, given by: $\Delta H = (S_o - S)\,\Delta X$, where ΔH is the total drop height requiring structural control, S_o is the original channel slope, S is the estimated equilibrium slope, and ΔX is the length of the channel between structures.

- Top width of no less than 5 ft.

- Energy dissipation should be provided at the downstream toe of the structure by a small plunge pool and large rocks.

Erosion and Sediment Controls

Design techniques for erosion and sediment control structures including straw barriers, silt fences, and mulching are described in the *WSSRAP Chemical Plant Surface Water and Erosion Control Report* (Ref. 47). Erosion control mats and filter cloths should be designed in accordance with manufacturers' specifications.

Applicable Codes and Standards

Applicable codes and standards and other applicable documents are:

- DOE Order 6430.1A, *Site and Civil Engineering*
- DOE Order 5400.5, *General Environmental Protection Program*
- American Society for Testing and Materials (ASTM)
- *WSSRAP Surface Water Management Plan* (Ref. 36)
- WSSRAP Project Procedures (including NQA-1 requirements)

During detailed design, construction specifications will be developed to address the design elements listed above.

5.1.6.9 Site Drainage System Analysis. Design of the site drainage system must be closely coordinated with other site designs. In particular, these other design activities include:

- Site roads.
- Disposal facility construction.
- Soil and sediment excavation activities.
- Construction of the CMSA.
- Stockpile of waste materials in the Ash Pond spoils area.
- Site closure and post closure.

Possible conflicts could exist between site drainage designs and designs associated with the above activities. These conflicts will primarily result from grading designs that differ from the proposed drainage patterns shown on Figures 5.1.6-3 through 5.1.6-7.. For instance, grading design of dirty and clean haul roads may interfere with gravity drainage of runoff to either contaminated or noncontaminated discharge points. This conflict would result because of the cut-and-fill balances required for road construction. Other activities may pose similar conflicts. To the most practical extent possible, other general site designs should allow drainage to flow as shown on Figure 5.1.6-3 through 5.1.6-7. Permanent drainageway design should also consider the geomorphological setting of the site.

5.1.7 Borrow Materials

5.1.7.1 General. Borrow materials are required for construction of the disposal cell and related facilities as part of the remediation of the chemical plant operable unit. Borrow materials will be used for the construction of the following items (the section numbers in parentheses provide additional details pertinent to the item):

- Foundation preparation for disposal facility (see Section 5.2.4)
- Cover (Section 5.2.7.2)
- Bottom liner and leachate collection and removal system (LCRS) (Section 5.2.5)
- Clean-fill dikes (Section 5.2.7.3)
- Site roads and construction material staging area (Section 5.1.4)
- Site restoration and site grading (Section 5.4)

Most of the materials will be obtained from off-site sources. However, some minor amounts may be available from on-site foundation excavations.

The purpose of this section is to identify the design characteristics and required volumes according to current design, recommend testing to ensure that the design requirements are met, develop a conceptual borrow plan, and identify approved sources for the different borrow material types. These items are addressed in the following sections. Finally, a summary of the design criteria associated with the acquisition of the borrow materials and an outline of the specifications is provided.

Table 5.1.7-1 indicates the design feature location, component and function, and material type (including USCS symbol) for each of the borrow material types required in the current conceptual design. The required in-place volumes for each material type needed in the most current design (a partially below grade cell) are presented in Table 5.1.7-2. Volume requirements for both the CSS and VIT treatment alternatives are noted. It is evident that the VIT cell requires less borrow materials, because the waste volume generated by the VIT process is considerably less than the CSS processes, resulting in a smaller disposal cell.

5.1.7.1.1 Functional Requirements. The component functional requirements for each borrow material type based on the designs of the various items discussed in other appropriate sections are listed in Table 5.1.7-1. Based on the component functional

requirements, these materials have been classified in the following broad material categories for ease of discussion.

1. Low-permeability material – Radon barrier, infiltration barrier, basal clay bottom and foundation preparation - limit quantity/rate of fluid exiting layer.

2. Rock or gravels/cobbles – Riprap and biointrusion - provide stability and durability.

3. Sands or gravelly sands – Drains, filter, beddings, base, subbase - provide separation, compatibility and lateral transport of fluids.

4. General fill – Clean-fill dike, site restoration, rooting medium, Layer 2 - provide materials for stability and allow vegetative growth.

5. Organic rich soil – gravelly topsoil, rooting medium Layer 1 - promote vegetative growth.

5.1.7.1.2 **Performance Requirements**. From a performance requirement standpoint, the different borrow material types may be classified into two categories:

- Borrow materials that are critical to the satisfactory performance of the disposal cell for its design life. The disposal cell and other associated facilities will be designed for a design life of 1000 years, to the extent practical, and in no case for less than 200 years (40 CFR 192(a)).

- Other borrow materials. These are materials that are not critical to the satisfactory performance of the disposal facility for the total design life. These include the site roads, with a design life of 30 years, and the CMSA, which has to withstand only a design life of 10 years.

To achieve these performance requirements, each component must be designed and constructed to the required design criteria and specifications, as outlined and discussed in earlier sections. The clay bottom, and the infiltration and radon barrier will be designed and constructed to eliminate potential adverse effects from the estimated differential settlements. The rock for riprap and biointrusion, and the sand and gravels for filter, drains, and bedding shall

be selected based on petrographic analysis and rock quality tests to ensure that they meet the durability requirements over the design period. This is determined by the procedures developed for Uranium Mill Tailings Remedial Action (UMTRA) and presented in Table 5.1.7-3. These design requirements are listed in Table 5.1.7-1 and generally based on earlier studies, most prominently *Supporting Study 6A, Borrow Area and Soils Selection Criteria* (Ref. 20). They have been modified to conform to the most current design, as appropriate.

5.1.7.1.3 Identification and Evaluation of Alternatives. The different types and volumes of borrow materials required, as listed on Tables 5.1.7-1 and 5.1.7-2, respectively are based on previous studies (Ref. 48, Ref. 49, and Ref. 53). They represent the required design characteristics for each component, based primarily on minimal performance needs as determined for the UMTRA project. The design characteristics reflect the appropriate performance requirements as well as regulatory requirements and construction constraints. Evaluation of alternatives for each component, therefore, is not within the scope of this section. This section addresses only the various alternatives for obtaining the different borrow materials from on-site and off-site sources, and making them available to the site for final placement. These are discussed in the following sections.

Observational Method and Data Assessment Needs

The major technical uncertainty is that the lists of borrow material types, the required volumes, and design properties are based on the most current version of the ongoing design. Therefore, changes in the design will consequently affect the types and volumes of materials required.

MVE Table 5.1.7-4 lists the potential deviations caused by changes in design. The greatest impacts would stem from changes to the configuration of the cell (height, footprint area), dictated by revised estimates of waste volume. The potential for relaxation of permeability requirements for the infiltration barrier is also significant.

MVE Table 5.1.7-5 addresses the additional data necessary to resolve the aforementioned uncertainty issues. Most of these issues will be resolved once the cell design criteria are finalized.

5.1.7.2 Materials Selection and Testing Criteria. To meet the functional and performance requirements discussed in Sections 5.1.7.1.2 and 5.1.7.1.3, the borrow materials will be obtained by selectively excavating and/or processing (e.g., crushing and/or screening for rocks and gravelly soils) at the approved borrow sources. Selection of the appropriate borrow sources is based primarily on criteria developed in *Supporting Study 6A* [Ref. 20]. The selection process is ongoing (*Supporting Study 5A, Borrow Area Investigation* [Ref. 51] and 5C, *Borrow Area/Material Selection Phase II* [Ref. 52]). The process of borrow source selection and the status of the present studies are discussed in greater detail in Section 5.1.7.4. Concurrent with the borrow material production, the field staff will perform various types of tests to ensure that the borrow materials meet the required material characteristics necessary to satisfy the design criteria. If test results indicate that the processed material will not meet the desired criteria, the material will be rejected. In such a situation, a new location and/or a new zone within the same borrow source will be tested. In the very unlikely event that field test results and other available information indicate that the materials available at the present location are not satisfactory, a new borrow source will be required.

The test methods (including test specifications such as American Society for Testing and Materials designations), frequency of tests and required properties to be employed during borrow operations for each type of borrow material are summarized in Table 5.1.7-6. The testing program and the properties desired are based on experiences gained on other hazardous waste projects. In particular, the experiences gained at the UMTRA project, a similar project involving substantial earthwork for the encapsulation of radioactive materials, were extensively utilized.

It should be noted that the tests designated for field verification of the borrow materials should be those performed easily, ideally in a field laboratory, and with a quick turn-around time (say, within 24 hours). Tests such as permeability (saturated hydraulic conductivity) are therefore not suitable for the purposes of field verification. Whether the required design characteristics, such as permeability are met, will be determined by other simple tests, such as Atterberg Limits for clayey soils, based on previously established correlations between Atterberg Limits and permeability for the soils in question. Such correlations are expected to emerge from *Supporting Study 5A* (Ref. 51). Therefore, for the source material, the required properties and associated tests during borrow operations, as noted in Table 5.1.7-6 may be different from that noted in Table 5.1.7-1.

The frequency of tests should ensure, to the maximum extent possible, that the placed materials meet the desired characteristics. The frequency should be based on the expected variability of the in situ material, relative to the characteristics desired, and the nature of the structure/foundation in question. An MVE session was conducted to evaluate the alternatives for the strategy to determine the frequency. The results of the MVE session are presented in MVE Table 5.1.7-7. The preferred alternative is the predetermined specified frequency that is conventionally used. This alternative is preferred over a statistical procedure for determining frequencies. It should be emphasized that the frequencies noted herein are recommendations only, and may be modified during final design (Title II design).

Observational Method and Assessment of Data Needs

MVE Tables 5.1.7-8 and 5.1.7-9 present the observational method and assessment of data needs for the preferred alternative. The extensive field and laboratory investigation presently underway for *Supporting Study 5A* (Ref. 51), and similar studies planned for the preferred borrow source in *Supporting Study 5C* (Ref. 52), will address the items discussed in these tables.

5.1.7.3 Required Types of Borrow Materials. The different types of borrow materials required for the proposed remediation work, their functions, and placement locations are identified in Table 5.1.7-1. To maintain an efficient project operation, the appropriate borrow material should be available for placement without delaying the construction schedule. In view of the large volume of borrow materials required, and the limited space available for storage (see Sections 5.1.4 and 6.1.4), borrow material production and delivery to the site will run concurrently with the placement of the materials in the final location. Also, double handling will be avoided to the extent practicable. Therefore, borrow material delivery and storage will be carefully planned and scheduled. The planning and scheduling will be in conformance with the Cost/Schedule Document (CSD) of the CDR.

Figure 5.1.7-1 presents a schematic of borrow material requirements. The present plans are for a phased construction; there will be two phases for a VIT cell and three for a CSS cell. Cell construction, which requires the majority of the borrow material, will span all phases. A discussion of the construction phases is presented below. Prior to cell construction, the required site roads and the CMSA should be in place to facilitate the delivery of the borrow material for cell construction. Therefore, the first demand for borrow materials will be for the aggregate base and subbase material for the site roads and the CMSA.

The cell construction will start with the construction of the CFD and the preparation of the cell foundation. These activities will proceed somewhat concurrently.

Prior to waste placement, the cell foundation area will be excavated to the desired depth and the foundation will be prepared, as discussed in Section 5.2.4; the basal liner and the LCRS will be constructed thereafter. Foundation preparation will consist of excavation and removal of building foundations, sewers, and contaminated soils from below the designated grade for the foundation. The holes left by the excavations will be backfilled with suitable compacted low permeability materials to ensure that the low permeability characteristics of the foundation soils are not compromised. Foundation preparation will be performed all at once for both Phase I and Phase II areas. Foundation preparation is not required for Phase III. For the partially below grade option, which is presently planned, adequate quantities of the low-permeability material will be available from the required on-site excavations. If, however, the at grade option is chosen, additional low permeability material from off-site sources will be required.

Construction of the clean-fill dike (CFD) will also start before waste placement. A large volume (1.6 million cu yd) of general fill is required for the construction of the clean-fill dike for the 1.5 million cu yd CSS disposal cell. The construction is planned to be almost continuous (except for the mandatory winter shutdown) for Phase I and II, over a period of more than one year. This will be best achieved by delivering the general fill material directly from the borrow source to the final placement location, at a rate commensurate with the construction schedule requirements. The production (excavation) of the material will therefore be coordinated with the construction demands, and any stockpiling and processing, (e.g., drying) that may be required will be accomplished at the borrow source, before transportation and delivery.

The construction of the basal liners and the LCRS following foundation improvement will require low permeability materials for the basal liners and the drainage and filter materials in the LCRS. All of these materials will come from off-site sources. Construction activities for Phases I and II will last approximately eight months, with one phase essentially following and slightly overlapping the other.

Cell closure activities are not scheduled for the first 2.5 years of construction. Also, in accordance with the CSD, no other activity involving borrow materials will be underway during cell closure. Therefore, judicious use of the CMSA may be made for the cell closure. Cell closure (or cover construction) will require low permeability materials for the radon barrier and

the infiltration barrier, rocks for the side slope, riprap and the top slope biointrusion layer, topsoils for vegetation growth on the top slope, and various types of sandy soils for bedding/filter/drainage materials (see Tables 5.1.7-1 and 5.1.7-2).

Finally, if a Phase III (closure phase) is required, these activities will be repeated in the same general sequence. As shown in the table, this work is not expected to start within the first two years of construction. During site closure only general fills for site grading will be required.

5.1.7.4 Location of Approved Sources.

5.1.7.4.1 Low-Permeability (Fine-Grained) Material. The ongoing low permeability borrow investigation (Ref. 52) identifies the preferred borrow source and transportation alternative for the low permeability materials to be used for foundation improvement, the basal liner, and the radon and infiltration barriers for the top cover. The selection process is based on the criteria developed in *Supporting Study 64* Ref. 20). It will address the borrow material storage during excavation and site restoration at the end of the project. MVE Table 5.1.7-10 summarizes the alternatives, the criteria utilized, and selects the preferred alternative for the borrow source. Figures 5.1.7-2 and 5.1.7-3 identify the areas considered in this evaluation.

As shown on MVE Table 5.1.7-10, a portion of the Weldon Spring Conservation Area owned by the MDOC is the preferred alternative. The preferred area, shown on Figure 5.1.7-3 is about 1 mi from the site, along Missouri State Route 94. The material will be transported to the site by off-highway vehicles using a dedicated haul road (to be constructed) from the borrow source shown in Figure 5.1.7-4. Additional details of the preferred transportation mode are discussed in Section 6.1.7.4.

Geotechnical data in the area indicate generally a 1 ft to 2 ft layer of topsoil, underlain by clays to a depth of 15 ft to 50 ft (average of about 30 ft) which in turn is underlain by bedrock. The clays are generally uniform and of medium to high plasticity, except for the occurrence of low plasticity clays in the upper 5 ft to 8 ft in some areas; the volume of material available is more than adequate. A typical cross-section of the soils in the area is presented in Figure 5.1.7-5. There is no indication of a water table in the area. The MDOC is agreeable

to use of this area as borrow source, thus, using the criteria listed on MVE Table 5.1.7-10, this area is the preferred borrow source.

Observational Method and Assessment of Data Needs

MVE Tables 5.1.7-11 and 5.1.7-12 present the observational method and assessment of data needs for the preferred alternative. It should be emphasized that an extensive field and laboratory soil investigation program is underway at the preferred borrow source, as part of *Supporting Study 5A* (Ref. 51) to determine the volume and quality of the available low permeability materials. It is highly unlikely that this source will be found unsuitable.

5.1.7.4.2 Granular Materials. Since the selection of granular materials will be based on the previously established UMTRCA rock quality standards, no additional value engineering methods are required. Granular materials (rock and sand) will be used as riprap for the side slopes of the disposal cell, the biointrusion layer for the top and side slopes, various filter, drainage and bedding layers, and as base and subbase for the site roads and the CMSA. Another extensive study (*Supporting Study 5C* - Ref. 52) is underway to identify and evaluate suitable sources for these materials. Several sites have been studied; a list of the sites studied is presented in Table 5.1.7-13, and a map of the locations is presented in Figure 5.1.7-6. The studies have generally consisted of field reconnaissance and collection of basic data, e.g., rock type, available volume, distance from the site, and site accessibility. Only existing commercial sources (e.g., no development of new quarries) are being considered, since several viable commercial sources were identified. Preliminary findings (Ref. 53) indicate that the limestones in the area (Ordovician to Mississippian age) are marginal to unacceptable in rock quality and additional tests are planned. A rhyolite source appears promising, but is 136 mi away and may require rail transport. Also, preliminary data indicate a significant radioactivity level in the rhyolite which may disqualify the source. The sand/gravels from the existing glacial deposits along Mississippi River and the residual chert along the Meramec River appear to be suitable both from gradation and rock quality standpoints.

Suitability of the candidate sources for each borrow material type are being evaluated in *Supporting Study 5C* (Ref. 52). The evaluation will be based on:

- Distance from the site and accessibility (presence of roads).
- Sensitivity to environment or archaeological concerns (e.g., permitting difficulties).

- Rock quality (as discussed in Table 5.1.7-3).
- Available gradations.
- Available volume.
- Processing of rock or sand required (e.g., crushing, screening).
- Site restoration requirements.

A detailed discussion on the evaluation process is presented in *Supporting Study 6A* (Ref. 20). As discussed in the supporting study, commercial sources will be given priority, in which case some of the criteria will not apply.

A preferred source and an alternate source will then be designated for each borrow material type (the same source may be preferred for more than one borrow material type). This study will ensure that the preferred and the alternate sources designated are in compliance with all environmental rules and regulations of the State of Missouri. Once the preferred sources have been identified, additional investigations of the preferred sources will be performed consistent with the recommendations in *Supporting Study 6A* (Ref. 20) to determine the available volumes and quality of the products. This will be done for both the preferred and the alternate source. Should the preferred source prove to be inadequate for some reason, the alternate source can then be used without much additional work.

Observation Method and Assessment of Data Needs

The preferred borrow source is expected to provide a sufficient volume of the appropriate borrow material of acceptable quality. If, during the production of the materials it is determined that borrow material is not adequate, the next alternative source designated by *Supporting Study 5C* (Ref. 52) will be investigated and developed. The specific questions in such a case are whether sufficient volume of appropriate material is available at the new source, and whether the rock quality standards are satisfied. There is only a medium probability of occurrence of such a situation.

5.1.7.4.3 General Fill. The greatest demand for general fill material (approximately 1.6 million yd^3 for the minimum excavation cell configuration and 1.0 milion yd^3 for the partially below grade configuration) is for the CFD. Some general fill is also required for site restoration. A minor volume of general fill material may be available from the required on-site foundation excavations; therefore, off-site material may be required. The sources selection

criteria, and alternative selections are the same as for clay borrow, because it is more economical to obtain both borrow materials from a single source.

The Weldon Spring Wildlife Area (Area No. 3 in MVE Table 5.1.7-10) has been designated as the preferred source for the general fill borrow material. Development of an area of approximately 204 acres is planned to provide sufficient material. Previous studies (Ref. 18) indicate that the soils in the area are mainly in clayey soils.

The scope of *Supporting Study 5A* (Ref. 51) is being expanded to evaluate and address the suitability of this area for providing both the general fill for the CFD and the low-permeability material. The study will evaluate hydrologic, geotechnical, and geomorphological characteristics of the site, including additional soil borings and laboratory testing. This data will help ensure the suitability of the site for its intended purpose. *Supporting Study 5A* will also help in the development of a borrow operations plan for this study. The borrow operations will address:

- The area to be fenced and the location of gates.
- Temporary roads, and staging and processing areas.
- Excavation plans, including phasing, to minimize disturbances.
- Storage and stockpiling of the different materials to be obtained from this area, including areas for processing the materials (e.g., drying), if required.
- Runoff control during operations: provision of sediment structures.
- Final restoration, consistent with the requirement of the MDOC and in conformance with the surrounding environment.

The mode of transporting borrow material to the site is addressed in Section 6.1.7.3. Present plans and preliminary findings as they relate to the borrow operations for this area are discussed in appropriate sections of Section 6.1.7.

Observational Method and Assessment of Data Needs

The observational method and the data quality objectives for the general fill borrow material are presented in MVE Tables 5.1.7-14 and 5.1.7-15. The greatest uncertainty lies in the availability of the areas. This uncertainty should be resolved at the earliest possible date.

5.1.7.4.4 Gravelly Topsoil and Rooting Medium Layers. Three different soil types are addressed in this section.

- Gravelly topsoil – should contain 15% to 30% by weight of fines (minus 200 sieve), and 50% to 70% by weight, of 1-in. to 2-in. rock. It should also contain at least 2% organic matter. Selection of the exact percentages of gravel and fines will be determined by a cover test plot during final design.

- Rooting medium Layer 1 – loam, as defined by agricultural terminology with at least 5% organic matter.

- Rooting Medium Layer 2 – should contain at least 20% clay size particles (less than 0.002 mm).

These descriptions are based on *Supporting Study 6A* (Ref. 20).

No supporting study has been performed to determine the available sources for these materials. However, the following recommendations may be made, consistent with the present plans.

Approximately 2 ft of the Weldon Spring Conservation Area is covered by topsoil (e.g., high organic content). This soil is likely to be unsuitable as general fill, particularly for the CFD, due to potentially high organic content. These soils have to be removed to reach the underlying general fill or the low permeability material. However, the topsoils may be used as effectively as rooting medium Layer 2 soils because they are generally clayey, and there is no constraint of organic content for rooting medium Layer 2 soils. Part of the topsoil layer will be used as topsoil for seeding, as part of the restoration of the Weldon Spring Conservation Area. Nevertheless, a large volume is expected to be available for use as rooting medium Layer 2 soils.

The rooting medium Layer 1 soils and the gravelly topsoil will have to be imported. The required volumes of gravelly topsoils and rooting medium Layer 1 soils are not large. It is expected that the gravelly topsoil will require mixing of gravels with fine grained soils with at least 2% organic content, since it is very unlikely that the required gradation will be available in nature.

Additional studies are required to ascertain that the plans for rooting medium Layer 2 soils discussed above are feasible, and to identify sources for the gravelly topsoil and rooting medium Layer 1 soils.

5.1.7.5 **Design Criteria and Specifications**. The design criteria associated with the acquisition of the borrow materials involve:

- Identification of the appropriate design properties of the materials required to fulfill the function and performance requirements of the borrow material in question, e.g., permeability requirement for the bottom liner low permeability material (Table 5.1.7-1).

- Identification of the in-place volume of material required for the borrow material type (Table 5.1.7-2).

- Identification of approved borrow sources which will supply the desired volume of material with the desired properties (Section 5.1.7.4).

- Establishment of selection and testing criteria to be used during the production of the borrow materials in order to ensure that the materials are appropriate (Table 5.1.7-6).

Table 5.1.7-16 lists the specifications required for acquisition of borrow material.

5.1.8 Other Facilities

5.1.8.1 General. "Other facilities" are defined as facilities or processes required to support remedial action activities at the Weldon Spring site that are not directly related to the construction of the disposal cell and the associated waste treatment facilities. These facilities can be categorized as follows:

- Facilities that already exist and will continue to function in their present capacity. Table 5.1.8-1 lists and briefly describes each of these facilities.
- Facilities that are being designed or constructed.
- New facilities that are being proposed.

In the following subsections, proposed improvements and upgrades to existing or planned other facilities are described, and the proposed new facilities are evaluated.

5.1.8.2 Power Utilities. Three existing overhead electrical power lines serve the Weldon Spring site (see Figure 5.1.8-1). A north feeder serves the subcontractor trailer area, composite building, shower trailers, and a decontamination pad. An east feeder splits off the north feeder and serves the main guardhouse and the controlled area access gates. The south feeder serves the administration building, support trailers, and SWTP Train 1.

The existing electrical system at the site is near capacity. Union Electric Company, the local power company, has informed the PMC that it may not be able to furnish additional power over the existing incoming feeders, and has asked the PMC to evaluate the project's current and future power needs.

Current and future electrical loads and alternatives for upgrading the existing distribution system are being evaluated (Task 219, Future Electrical Load Requirements). These loads and alternatives will be submitted to Union Electric Company for review and analysis. Alternatives for evaluation include:

- Upgrading the existing Union Electric Company substation and distribution lines.
- Constructing a new user-owned substation on site.

- Constructing a new utility-owned substation on site.

Union Electric Company will evaluate these alternatives, based upon the utility's overall system needs and cost evaluations, and will direct the PMC on how to proceed with system upgrades.

If natural gas is required for a fossil fuel-heated vitrification process, a new gas line can be connected to the existing Laclede Gas Company main line, which ends on the east side of the Missouri State Route 94 right-of-way near Francis Howell High School.

5.1.8.3 Water Distribution Utilities. Water is provided to the site by two St. Charles County water mains that run parallel to the northwest side of Missouri State Route 94 and the Army road (Figure 5.1.8-2). Ample water is available for fire protection and any additional needs.

The six connections to these water mains supply the administration building, the composite building, the SWTP, Building 434, the TSA transfer station, and a fire hydrant on the west side of the TSA. Extensions to these existing water main connections will provide water to two proposed water-truck filling stations (Section 5.1.8.11), the proposed waste treatment facility, SWTP Train 2, and any other facilities on the south half of the site.

If water is needed on the north end of the site near the CMSA and the Ash Pond area, an additional connection could be made to the St. Charles County water mains near the intersection of the proposed borrow source haul road and Missouri State Route 94. A water-truck filling station could be constructed near this intersection, or a water line could be extended along the borrow haul road to the CMSA and the Ash Pond area to provide water for CMSA operations and dust control. A preliminary engineering analysis should be performed to determine which of these alternatives is the most cost effective.

5.1.8.4 Sewer and Storm Sewer Utilities. Most of the existing chemical plant sewer systems (Figure 5.1.8-3) will be removed during the excavation and removal of the site utilities (Section 5.1.2). Only a small portion of the storm sewer system that serves the administration area will remain in service. Two sections of the existing chemical plant storm sewer system will remain in place to serve the administration area during remediation of the chemical plant site.

One section is a 36-in.-diameter underground piping system that collects storm water from the PMC parking lot, composite building area, and an area within the controlled area near Buildings 103, 105, 407, and 410. The water in the pipeline flows southeasterly out of the controlled area and northeasterly through the administration area to an outfall inside the controlled area. Discharge from the outfall flows over the ground surface to the Frog Pond.

The other section collects storm water from the administration building area, which is then pumped to an outfall on the southwest corner of the administration area. This system is independent of any chemical plant cleanup activities and does not require expansion or upgrade.

A section of the 36-in.-diameter storm sewer piping, within the controlled area and upstream of the administration building, will be removed during foundation and utilities removal. This piping should be plugged at the controlled area fence line where it enters the administration area, and the remainder of the system should be left in service. Samples should be collected from the remainder of the piping system in the administration area system and tested for possible contamination. If contamination is detected, remediation may be necessary. If no contamination is detected, the system should be certified as clean. In addition, the outfall and downstream piping should be protected during underground utility removal operations and disposal cell construction.

A sanitary sewer system and an industrial waste system also serve the administration area. The industrial waste system collects wastewater from the shower trailers and may require remediation at the end of construction activities. These systems will not be disturbed by the chemical plant remediation activities, and will remain in service during construction activities.

Any other sanitary or industrial wastes that are generated outside of the administration area will be collected in storage tanks and hauled to the appropriate treatment facilities on site.

5.1.8.5 Laboratory Facilities. An analytical laboratory (also called the radiochemistry laboratory) operates in a small space in the back of the administration building (Figure 5.1.8-4). This laboratory provides cleanup verification support, monitors breathing apparatus filters, and analyzes radioactively contaminated solids that are found on the site. A small number of samples are quickly tested in the laboratory to provide preliminary results. These preliminary results are then verified by more extensive testing of many samples at off-site contract laboratories.

Although the laboratory has a good record of providing dependable, accurate results, and is expected to continue operating at its current capacity, it is crowded and inefficient due to the lack of space. Offices are located in the same room as the testing laboratory where dangerous chemicals and radioactive materials are handled. Also, as cleanup activities increase, additional laboratory personnel may be necessary, further complicating the already crowded laboratory operation and potentially increasing worker safety concerns.

For these reasons, the analytical laboratory should be expanded to ensure an efficient and safe operation. Figure 5.1.8-5 shows a proposed floor plan for a new analytical laboratory. This floor plan could be adapted to the space occupied by the current laboratory, if some of the existing adjacent office space were made available.

Other laboratories necessary to support the remedial action activities include:

- Quality Control/Physical Testing (QC/PT) laboratory. This facility will provide the quality control testing services necessary to ensure that construction materials are installed according to the construction drawings and specifications. Physical testing will also be conducted to verify front-end studies of various types of materials (such as SWTP sludges) that will be treated in both the pilot- and the full-scale waste treatment plants. Figure 5.1.8-6 shows a proposed floor plan for the QC/PT laboratory.

- Subcontractor-provided geotechnical laboratory. Material testing services will be conducted at the clay borrow sources to ensure that the borrow materials meet specifications. More than one geotechnical laboratory may be required and should be furnished by subcontractors on an as-needed basis. Figure 5.1.8-7 shows a proposed floor plan for a geotechnical laboratory.

Alternatives for locating the QC/PT and analytical laboratories (Figure 5.1.8-4) are:

- House the QC/PT and the analytical laboratories in separate areas.
- Combine the laboratories in a facility within the administration area.
- Combine the laboratories in a facility near the south end of the chemical plant site.

An MVE session was conducted to evaluate these alternatives (MVE Table 5.1.8-2). The main evaluation criteria are:

- Ease of delivery. Location should provide easy access for delivery of materials to be tested.

- Minimize congestion. Overall site congestion should be minimized by placing laboratory facilities in areas least affected by long-term activity.

- Personnel access. Provide easy access for personnel to get to and from the laboratory.

The preferred alternative is to build a new facility that will house the QC/PT and analytical laboratories at the south end of the chemical plant site. Ideally, the laboratories would be housed in two separate facilities; however, these laboratories can be housed in one large structure and designed to fit the available space between the U.S. Department of Energy (DOE) fence and the perimeter road. The two laboratories would share parking areas, utility services, security features (such as yard lighting), and storage.

Access to and from the analytical laboratory will be somewhat more difficult for laboratory personnel. However, this alternative minimizes congestion in the administration area, provides additional office space in the administration building, and may allow the two laboratories to support each other.

5.1.8.6 Leachate Storage and Treatment Facilities. During disposal cell construction, rain falling on exposed waste will generate significant quantities of leachate. Leachate that does not meet release criteria must be collected in sumps and stored in holding ponds for treatment prior to being released from the site. Rainfall contacting the CSS product may produce a leachate with high nitrate concentrations. High-nitrate leachate will be pumped to Raffinate Pit 1 or 3, where it will be stored for treatment in SWTP Train 2. Other leachate may be stored in any of the raffinate pits or in contaminated-water storage ponds and treated in either Train 1 or Train 2.

After the disposal cell is closed, a small quantity of leachate will continue to be collected, stored, and treated. During the active cell monitoring period (30 years to 50 years after cell

closure), no more than 30,000 gal/year to 40,000 gal/year of leachate is expected to be generated from the cell. This leachate will be stored in a collection tank (approximately 50,000 gal).

Three alternatives for long-term treatment of the leachate (MVE Table 5.1.8-3) are:

- Continue to treat in Train 2.
- Purchase a small mobile treatment plant that uses the same process as Train 2.
- Issue a maintenance contract for treatment using the same treatment as Train 2.

All of the alternatives employ the same technology, and all require storage facilities and entail periodic treatment. Leachate quantities will be somewhat larger in the first few years after cell closure, because of the excess construction water that remains in the cell after closure, but will decrease over time. Storage and treatment must continue until leachate is no longer generated or until authorities deem that the leachate is no longer a threat to the environment.

An MVE session was conducted to evaluate these alternatives. The main evaluation criteria were:

- Minimizing life-cycle cost including initial capital outlay, operation, maintenance, and salvage value.
- Minimizing maintenance.
- Maximizing dependability.

The preferred alternative is to issue a contract for annual treatment using mobile equipment and a process similar to the SWTP Train 2. Leachate will be treated and the subcontractor will remove the sludge or filter cake collected for off-site disposal in accordance with current DOE directives. This alternative minimizes life-cycle cost, maintenance, and requires no on-site equipment storage. MVE Table 5.1.8-4 lists the potential deviations associated with the treatment of leachate.

Although SWTP Train 2 is already in place, it is too large and would be too expensive to maintain for the sole purpose of long-term treatment of leachate. However, it should be kept

on-line to treat construction water that exits the cell for a year or two after cell closure. After most of the cell construction water is drained, a contract should be issued for treating small quantities (less than 40,000 gal/year) of leachate that may be generated for many years.

5.1.8.7 Covered Storage Facilities. Covered storage will be required for materials regulated under the Resource Conservation Recovery Act (RCRA) and *Toxic Substance Control Act* (TSCA) and for ACM, contaminated construction hand tools, and other materials. There are two existing covered storage structures within the controlled area: Building 434, which houses RCRA and TSCA wastes, and Sea-Land and roll-off containers. The containers provide general storage for ACM, piping, and other wastes such as contaminated used lumber, hardware, file cabinets containing contaminated documents, tools, and other miscellaneous items to be saved or reused.

Items to be saved are records that are too contaminated to be kept in office files, but that are necessary for historical records. Reusable items are tools, equipment, and materials used by site personnel for day-to-day operations and maintenance activities.

5.1.8.7.1 RCRA and TSCA Regulated Materials. Building 434 contains 2,100 drums of waste and has a maximum capacity of 3,400 drums. A new roof, sprinkler system, and additional secondary containment areas are being constructed.

Of the 2,100 drums of waste stored in Building 434, only about 700 of the drums contain RCRA- or TSCA-regulated materials. The remaining 1,400 drums contain materials such as personal protective equipment (PPE) and do not require covered bermed storage. It is recommended these 1,400 drums be removed from Building 434 and placed in either the TSA or the MSA. Removing these drums will provide ample room to store the remaining RCRA- and TSCA-regulated materials that will be removed from the chemical plant area and the quarry.

5.1.8.7.2 Asbestos-Containing Materials. ACM has been removed from the chemical plant and is stored in Sea-Land containers located north of the existing chemical plant site. Once the first phase of the disposal cell is completed, the Sea-Land containers will be emptied, and the ACM will be disposed of in the cell. The empty Sea-Land containers may either be decontaminated and released from the site, reused, or placed in the cell. Sea-Land containers work well for storing ACM, but require a lot of storage space (about 2 acres of space

for .25 acre of storage). These containers are also used to store other materials; therefore, more containers may have to be purchased. Sea-Land containers will be used to store ACM.

5.1.8.7.3 **Miscellaneous Items.** Contaminated reusable materials, equipment, tools, and documents should be stored within the controlled area to minimize waste, conserve resources, and maintain control and security of important records. These items have been in contact with sources of contamination, but are still in good condition and may be reused, or must be stored within the controlled area, disposed of, or decontaminated and released from the site.

There are three alternatives for storing contaminated-reusable items:

- Continue to store these materials in Sea-Land containers.
- Designate an existing chemical plant building for conversion to storage.
- Construct a new storage shed.

An MVE session was conducted to evaluate these alternatives. Evaluation criteria listed in MVE Table 5.1.8-5 were to provide adequate storage area, minimize site congestion by placing storage facilities in areas away from other site activities, not increase waste volume, and ensure that storage space was available when needed.

The preferred alternative is to continue using Sea-Land containers to store miscellaneous items. If more storage space is needed, the gravel pad that supports the existing containers can be expanded and more containers can be added. When the containers are no longer needed, they should be emptied, decontaminated, and released from the site. Either long-term storage for the contaminated historical records must be provided or clean copies should be made, and the contaminated files placed in the disposal cell. This alternative provides adequate storage space, does not increase site congestion, does not increase waste volume, and is consistent with the current method of storage.

5.1.8.8 **Controlled Area Parking.** Organized controlled-area parking is needed at the area occupied by the TSA, SWTP, and waste treatment plant. As construction operations begin, this area will become more congested and the possibility of vehicular accidents will increase. Because no large areas are available in the vicinity, several small parking areas should be constructed. Figure 5.1.8-8 shows several possible locations for parking five to 10 cars and

trucks. Construction vehicles should be parked in work areas or along roads in designated turnout areas during off-hours.

5.1.8.9 Access Control. There are three access points (Section 5.1.5.2, Site Roads) to the controlled area (Figure 5.1.8-9). They are the main access at the composite building, a south entrance from the quarry haul road, and the SWTP access from the Army road. A north entrance at the CMSA is planned as a fourth access.

The main access at the composite building will continue to function as the primary entrance and exit point for personnel and light vehicles. Personnel shower facilities are also provided at this main access. Additional shower trailers will be installed as access requirements increase.

The quarry haul road entrance will serve clean trucks hauling waste materials from the quarry to the TSA. The SWTP access will continue to provide vehicle access to the SWTP and will also provide access for clean trucks delivering fly ash and cement to the waste treatment plant. The north entrance will provide access for delivery of clean construction materials to the CMSA and to the disposal cell construction area and will provide an additional exit point for construction equipment.

The main exit and release point for contaminated construction equipment is an existing decontamination pad near the quarry haul road entrance on the south side of the site. A second pad is proposed at the north entrance near the CMSA. Both of these pads are intended to provide complete decontamination for release of construction equipment from the controlled area. Two decontamination pads will be necessary during peak construction periods because some of the larger equipment may require up to two weeks for complete decontamination, which could delay release of equipment from the site.

In addition to the existing and proposed decontamination pads, it may be necessary to install additional pads to provide gross decontamination of equipment within the controlled area. Gross decontamination consists of removing soils and other materials from the exterior of construction equipment. Daily gross decontamination of equipment may be necessary or desirable to allow for routine maintenance and care of equipment. Gross decontamination may be similar to the type of cleaning which is typically performed on earthwork equipment for

highway construction projects, but with additional requirements for limiting the spread of contamination.

Gross decontamination of equipment should be performed in work areas using mobile and hand cleaning equipment. No other facilities will be necessary to perform these operations. Contractors performing these cleaning operations should be made responsible for providing any equipment necessary and controlling and containing any water or dust caused by gross decontamination.

5.1.8.10 Contaminated Construction Equipment Maintenance Area. An area for staging and maintaining contaminated construction equipment is needed within the controlled area (Figure 5.1.8-10). This area will be used to repair and perform major maintenance on construction equipment that operates within the controlled area. Equipment entering the area will receive gross decontamination to prevent the spreading of contaminated materials. This area will allow contractors to perform major maintenance and repairs on their construction equipment without complete decontamination and release from the controlled area.

From this area, construction equipment may either be repaired, maintained and sent back into the contaminated work area, or it may be further decontaminated and released from the site. A decontamination pad for gross decontamination should be located near the south entrance of the area. A second decontamination pad located at the north entrance of the area will provide complete decontamination facilities for release of construction equipment from the site.

Room is needed for three to four contractors to set up semipermanent repair shops and for storage of several pieces of construction equipment (1 acre to 2 acres). The area should be designed and equipped with power, water, lighting, storm-water drainage and collection of contaminated water, and adequate gravel surfacing.

The area should be removed when the MSA is removed during Phase II of the disposal cell construction. At that time, construction activities will be reduced and a small area near the CMSA should suffice for construction equipment maintenance.

5.1.8.11 Dust Control Facilities. Dust emissions during earthwork operations within the controlled area must be minimized. Methods for controlling dust on roadways and work areas are discussed and described in Section 5.1.5, Site Roads, and consist of using water

trucks to spray water or water augmented with a dust suppressant on dirt and gravel roadways, and possibly paving some of the more heavily traveled roadways.

Two water truck filling stations are being constructed in the controlled area. One is south of Building 434; the other is near the administration building, just inside the controlled-area fence. A third water truck filling station should be constructed at the north entrance (CMSA) of the site at the boundary between the clean and contaminated areas with the capability to serve both clean and contaminated trucks. This third water truck filling station would provide a convenient place to load clean water trucks serving the CMSA, the borrow source, and the borrow source haul road. This filling station would also provide a convenient filling point for contaminated water trucks working in the Ash Pond area and the disposal cell construction area.

Installing a fixed sprinkler system and a moveable sprinkler system in some of the long-term work areas was suggested as a dust control alternative.

An MVE session was conducted to evaluate these three alternatives. Listed in the MVE Table 5.1.8-6, the main evaluation criteria were that the system must be dependable, it must be easy to move, maintenance should be minimized, hand labor in contaminated areas should be minimized, and the system should cover large areas easily.

The preferred alternative is to continue to use water trucks, which require no manual labor or maintenance in contaminated areas, are very dependable, are mobile, and can cover large areas easily. Water trucks working in areas where materials are stockpiled should have the capability of watering from a distance. Pumper trucks with water cannons will be considered.

5.1.8.12 Pond Dewatering Facilities. No special problems are anticipated for dewatering the MSA and TSA holding ponds or other holding ponds. Minor amounts of contaminated water remaining in holding ponds can be collected using small pumps. Any sedimentation should be washed down and mixed with enough water to allow pumping. Minor amounts of sediment remaining after pumping should be collected in buckets and removed from the holding pond. These sediments should be transported to the waste treatment plant (Figure 5.1.8-2) for processing before final placement into the disposal cell.

5.1.8.13 Field Shelter. A small shelter building (Figure 5.1.8-9) is planned for installation near the quarry haul road entrance on the south end of the site. The shelter will provide a place protected from wind and rain for workers and subcontractors to review drawings and specifications. Workers in the TSA and the waste treatment plant area will use the shelter. Workers at the SWTP will use a field shelter that is proposed for construction as part of the Train 2 construction package. Electricity for lights and heat, a cellular phone, and a table will be provided. The shelter is not intended to be an office or storage room, but will be available for short field meetings.

A second field shelter will be installed at the north end of the site near the CMSA to serve workers involved in CMSA, borrow source, and material hauling operations.

5.1.8.14 Vicinity Properties Support Facility. Removal operations at most of the vicinity properties are expected to take anywhere from a few weeks to a few months. These operations will require temporary site security, access control, shower facilities, decontamination pads, potable water, sanitary sewer, storm water runoff control, and electricity.

Some of the smaller sites will require only a few days to clean up and may not need all of these support facilities. However, if complete support is not provided, provisions for transporting personnel to and from site support facilities will be necessary. Transportation for personnel may be necessary at the beginning and end of each shift, at lunch, and at scheduled breaks. Subcontracts for removal of vicinity property wastes should include plans and requirements for furnishing, operating, maintaining, and removing these support services. These facilities should be self-contained and must not rely on public utilities.

Temporary support facilities should be designed to have minimal impact on the surrounding environment. Provisions should be made for complete removal of these facilities, so that the presence of the facilities would be undetectable within two years after removal.

Figure 5.1.8-11 shows vicinity property locations and indicates which properties may require full support facilities and which may only require the transport of personnel to and from existing site support facilities.

5.1.8.15 Training Facilities. The DOE recently mandated new radiological training that requires extensive hands-on and classroom training for anyone carrying a dosimeter badge

at the Weldon Spring site. To accommodate these new requirements and the expected increased number of employees who will be working on site during the peak of the remediation process, additional training facilities are necessary.

WSSRAP training personnel recently visited the new Fernald Project Training Facility (a U.S. Department of Energy (DOE) radiological training center) and determined that, at a minimum, the Weldon Spring training facility (Figure 5.1.8-12) should include:

- Two classrooms, each equipped to accommodate 20 students.
- A large room for training exercises and for storing a large quantity of personal protective equipment.
- Office space with desks, tables, and cabinets for four training instructors.
- A dust-free graphics and video room with adequate electrical supply to power extensive video equipment.

As listed in MVE Table 5.1.8-7, alternatives for furnishing an adequate training facility are to expand the existing facility, construct a new facility on site, or lease space off site.

An MVE session was conducted to evaluate these three alternatives. The main evaluation criteria were that the training center should be located conveniently on the project site, should not contribute to site congestion, should be available for use as soon as possible, and the facility should be available for eight years.

The preferred alternative is to:

- Conduct a search in the project area to determine what existing off-site facilities may be available for lease. One other possibility may be that the existing Army training facilities could be improved and shared with the Army.
- Construct a new facility on the north side of the PMC parking lot, if a suitable off-site facility is not available.

5.1.8.16 Site Contaminated Water Balance. An order of magnitude contaminated-water balance was conducted (Ref. 54) to compare available retention pond storage and SWTP treatment capacity with expected average annual volumes of contaminated water runoff.

Assumptions

- SWTP Train 1 - design treatment capacity - 80 gpm; maximum treatment capacity - 100 gpm.
- SWTP Train 2 - design treatment capacity - 40 gpm; maximum treatment capacity - 50 gpm.
- SWTP Trains 1 and 2 are available for operation 95% of the time, as required by plant specifications, which is equal to 345 day/year, 24 hour/day.
- Annual rainfall is 35 in./year.
- Annual evaporation from ponds is 35 in./year.

Preliminary Results

Preliminary results of this evaluation (Tables 5.1.8-8 through 5.1.8-14) indicate that the SWTP and the mobile water treatment plant (MWTP) will be able to store and treat both the expected contaminated runoff and the water removed from cleanup operations in the raffinate pits. However, it must be emphasized that this study is preliminary and that it is based on average annual rainfall volumes. If average annual rainfall volumes are exceeded in any year, the existing facilities may not be able to meet the demand. A more detailed study is currently underway to refine and verify these results. If the detailed study finds the existing facilities are inadequate, three possibilities for increasing the contaminated-water handling capacity should be considered:

- Expand existing retention pond storage capacity.
- Increase SWTP capacity.

- Add a series of detention ponds and settling basins for detaining, testing, and releasing clean water from the site. The contaminated water would be stored in a isolated pond, treated, tested, and released as an acceptable discharge allowed under the NPDES discharge permit.

5.1.8.17 Design Criteria and Specifications

5.1.8.17.1 Applicable Codes and Standards. The following codes and standards are applicable to the design and construction of other facilities:

- WSSRAP Site Specific Health and Safety Plan
- OSHA Standards 29 CFR 1910 and 1926
- *American Society for Testing and Materials, ASTM*
- *The BOCA National Building Code/1990*
- *National Fire Protection Association, NFPA*
- *National Electrical Code, NEC*
- *DOE Standard on Fire Protection for Portable Structures, 1979*
- 40 CFR 761, Subpart D, *TSCA Storage Requirements*
- 40 CFR 264, Subpart I, *RCRA Storage Requirements for Containers*
- 10 CSR 25-7 (Missouri) *Regulations on Hazardous Waste Storage Facilities*
- DOE Order 6430.1A, *General Design Criteria*

5.1.8.17.2 List of Specifications. The following are recommended specifications for design and construction of the other facilities:

- Electrical
- Mechanical
- Earthwork
- Site preparation
- Utility excavation and trenching
- Sanitary sewer piping systems
- Storm sewer piping systems
- Temporary structures
- Modular structures

- Paint
- Insulation

5.1.8.18 Other Facilities Systems Analysis. Another objective of this effort was to identify work or tasks that must be performed to complete the remedial action, but are not addressed in other sections of the TID. As such, the work described in Section 5.1.8 is intended to fill any gaps that may exist in the design and construction of the disposal facility and the various support systems. However, a few issues should be addressed to avoid schedule delays and possible conflicts between operations:

- The administration area storm sewer system, discussed in Section 5.1.8.4, must be maintained and protected during removal of underground utilities and the cleanup of Frog Pond. Facilities and structures that are required to operate the storm sewer system should be clearly designated on the construction drawings as "maintain and protect." These include sections of the underground piping, the outfall structure, surface flow path, and Frog Pond,

- To ensure that ample storage capacity is available, materials not regulated under RCRA and TSCA should be removed from Building 434 before bulk waste removal begins at the quarry and before the dismantlement of the chemical plant building is further along.

5.2 Disposal Facility

5.2.1 General

One of the key remedial operations for the chemical plant operable unit is the construction of an on-site engineered disposal cell. Based on the results of previous studies, the on-site engineered disposal cell was selected as the preferred disposal alternative for the various site wastes described in Section 5.1.2. Six on-site disposal options were considered: lagoons, waste piles, landfills, vaults, cap/cover systems for in-place waste, and engineered cells. Details of the selection process, including the evaluation criteria and the rationale for selecting the preferred alternative, are presented in the *Engineering Analysis of Remedial Action Alternatives Phase I and Phase II* (Ref. 48 and Ref. 49).

The on-site disposal cell is designed to contain site wastes, including quarry wastes, and to isolate them from the environment, in compliance with Federal and State requirements for long-term waste management. Most of the wastes will require additional treatment prior to disposal. Two waste treatment alternatives are presently being considered: CSS and VIT. Disposal considerations for both alternatives are included in this section. The functional requirements for on-site disposal include all stability for up to 1000 years, to the extent reasonably achievable, but in any case for at least 200 years (longevity requirement); reduction of the potential for human and animal intrusions into the waste; isolation of the waste from the environment; and protection of air and groundwater from future contamination. The functional requirements for each disposal cell component are described in detail in the following sections.

Disposal cell design considerations include the location, type, size and configuration of the cell. These parameters are affected by site conditions, waste volumes, waste characteristics, and functional and performance requirements. The Weldon Spring site disposal cell will be located within the study area identified in the *Site Suitability Data On Potential Location of a Disposal Facility: Collapse Potential and Permeability* report (Ref. 16). The report indicates that the study area is a suitable location for the disposal cell. Therefore, for conceptual design purposes, the study area is also referred to as the site suitability area in this report. A detailed description of siting and site constraints that affect the cell design are presented in Section 5.2.2. The conceptual design for the disposal cell addresses two layouts: one for disposal of the CSS product, and the other for disposal of the VIT product. The cell layout pertaining to the preferred waste treatment method, when selected, will be used for Title II design.

Both the CSS and VIT products will be physically and chemically stable, and a single cell of identical design will work for either treatment alternative. Except for the cell size, the cell design for the VIT alternative is essentially identical to the CSS alternative. The smaller quantity of VIT product requires a smaller cell footprint, eliminating the area in the northern third of the CSS cell footprint. The only difference in cell design is the design capacity, because the two waste treatment methods will produce significantly different volumes. The disposal cell for the CSS alternative is designed for a waste containment capacity of 1.5 million cu yd, which includes a 50% contingency factor over the identified waste volume. The details and layout of the preferred cell for CSS treated waste are presented in Section 5.2.3. The cell design capacity for the VIT option is 1.05 million cu yd, also including the 50% contingency factor; therefore, the VIT cell will be substantially smaller than the cell for the CSS alternative. The preferred cell for the VIT option layout is described in Section 5.2.3.

A partially below-grade cell is the preferred design, based on optimization studies (see Section 5.2.3). This design incorporates provisions for meeting the State's siting requirements for a waste disposal facility, including the requirement for a minimum thickness of 30 ft of natural foundation material with a permeability of 1×10^{-7} cm/s separating the wastes from the uppermost regional aquifer, or alternatively, a suitable natural foundation material with a thickness of at least 20 ft that provides an equivalent protection of the aforementioned 30 ft of 1×10^{-7} cm/sec permeability against contaminant migration into the uppermost regional aquifer. In addition, the cell design provides an allowance for positive drainage at the leachate collection retention basin location.

Figure 5.2.1-1 presents a typical detailed section of the disposal cell showing the various components (foundation, leachate collection and removal system, clean-fill dike, and cover). The major cell components discussed above, including design features and governing criteria for each component, are listed in Table 5.2.1-1. On-site disposal options are presented in Table 5.2.1-2. Design features, governing criteria and evaluation process for each major cell component are presented in the following sections of this chapter. Operational concepts for the construction of each major cell component are discussed in Sections 6.2.2 through 6.2.6.

Technically, the foundation is not part of the disposal cell. However, it is important to the overall cell performance. A suitable foundation should provide underlying support for a disposal cell and additional capacity to retard potential contaminant migration. The site study area is suitable for the disposal cell foundation because the foundation materials include adequate thicknesses of relatively incompressible low-permeability soils consisting of the Ferrelview Formation (also referred to as Ferrelview clay) and clay till soil units. The overlying soil layers, such as topsoil, existing fill, organic/saturated soils and unsuitable loess will be removed. An option to improve the uppermost portion of the foundation soil (preliminary thickness of 5 ft) by removal and recompaction is considered because of the uncertainties regarding the permeability of the foundation soils. The uncertainties stem from the heterogeneous nature of geologic deposits, undocumented or improperly abandoned penetrations of the foundation soils, and the presence of contaminated groundwater extending beneath the cell footprint. An ongoing study, however (Warbritton and Carman, November 23, 1992, Appendix A), indicates favorable permeability values for both the Ferrelview clay and clay till layers. Conceptual details of the cell foundation design are described in Section 5.2.4.

Immediately above the foundation bottom and on the cell interior side slopes, a basal liner system comprised of a combination of liners and leachate collection and removal systems will be constructed to prevent leachate from escaping into the foundation. This system will collect and allow monitoring of the leachate generated. The leachate will be collected outside the cell in individual collection sumps and manholes connected to a leachate collection retention basin located outside of the northern end of the cell. Section 5.2.5 describes the design concepts for the basal liner system.

The site wastes, both treated and untreated, will be placed and stabilized within the cell in a controlled and engineered condition to provide a stable support for the cover system and to minimize settlement, volume occupancy, and radon emissions. Details on waste placement are presented in Section 5.2.6. In addition to the basal liners, the emplaced wastes will be contained by a perimeter encapsulation system, also referred to as the CFD, and covered with a multi-component cover system. The cover system and the CFD are designed to resist erosion, promote runoff, limit infiltration into the waste, minimize radon emissions, minimize long-term maintenance, minimize plant, animal and human intrusions into the waste, and reduce the risk to human health and the environment. Details of the CFD and the cover system are presented in Section 5.2.7.

Design for drainage control and water management during cell construction is presented in Sections 5.2.8 and 6.2.7. Operation and maintenance requirements during waste placement are addressed in Sections 5.2.9 and 6.2.8.

Technical uncertainties and operational requirements for each component are discussed within each respective section.

The waste boundary (limit) is shown on Figure 5.2.2-1. The waste will be at least 300 ft (buffer zone) away from the site boundary line, within the suitability area, and away from existing features which may interfere with the sequencing of the remedial operations. For conservatism in the conceptual design, the cell waste limit is set back further by limiting the toe line of an imaginary 3(H):1(V) slope projected from the outermost point of the emplaced waste not to extend beyond the siting limits stated above.

The preferred cell presented here for the CSS alternative occupies a footprint area of approximately 72 acres, and the cell bottom generally ranges from 5 ft to 12 ft below existing

ground level. The emplaced waste is about 22 ft to 28 ft thick, the cover system is about 10 ft thick, and the basal liner system is 6.5 ft thick. The total cell thickness is therefore about 39 ft to 45 ft. The height of the cell from the toe to the crest break line, averaged around the cell perimeter from adjacent finish grade, is approximately 43 ft. Because the elevation of the surrounding topography around the toe of the CFD is generally lower than the central portion of the cell foundation, the cell height is generally greater than the cell thickness at the adjacent locations.

The preferred cell design presented here for the VIT alternative occupies approximately 55 acres. The thicknesses for the excavation, waste, cover system, and liner system are essentially the same as for the cell for the CSS alternative. For the VIT operations, the waste boundary for the cell is identical to that of the CSS cell, except at the north end where it is located approximately 500 ft further south than for the cell CSS option.

5.2.2 Cell Siting

Siting the disposal facility involved evaluating the requirements and alternatives for the possible locations and the number of cells to be constructed on site. (For simplicity, the term "cell" is used hereafter to imply either "cell" or "cells"). The location of the disposal cell was selected based on the following additional environmental and physical restrictions:

- The cell waste limit must be situated within the study area designated in the *Site Suitability Data On Potential Location of a Disposal Facility: Collapse Potential and Permeability* report (Ref. 16). Hereafter, this area is referred to as the site suitability area.

- The cell must meet all siting constraints specified in the *Design Basis Memorandum* (DBM) (Ref. 55).

- The site selection process must comply with the Missouri Hazardous Waste Management Commission Regulations (10 CSR 25-7) and other applicable State and Federal regulations.

5.2.2.1 Functional Requirements. The function of the disposal cell is to provide on-site, long-term storage and isolation of contaminated waste materials associated with the remediation of the site.

5.2.2.2 Performance Requirements. The disposal cell will be sited entirely within the Weldon Spring site boundary and designed so that all applicable regulations and the general cell performance requirements and additional constraints cited below are met. To the extent practical, the selected cell location should :

- Avoid areas underlain by groundwater in which contaminant levels above background levels have been detected.
- Minimize the earthwork volumes required for construction.
- Avoid existing or proposed features that would interfere with remedial operations.
- Be at least 200 ft away from any known fault on which displacement has occurred in Holocene time (10 CSR 25-7).
- Have at least a 50-ft setback from the site boundary as required by the Missouri Solid Waste Management Regulations for sanitary landfill (10 CSR 80-3).

5.2.2.3 Performance Goals. In addition to the performance requirements discussed above, the cell location was selected based on achieving the following performance goals:

- The waste will be placed entirely within the cell and the established site suitability area (Ref. 16), and in addition, the cell siting will comply with the following:
  - The toe line of an imaginary 3H:1V slope projected outward from the outermost limit of the waste will be located at least 300 ft away from the site boundary, as agreed to by the State of Missouri (Ref. 56).
  - The above-mentioned toe line will also lie entirely within the site suitability area.

- The cell bottom, in relation to the underlying foundation, shall meet the State Regulation, Clause II or III, as stated below:

  - State Regulation, Clause II: No less than 30 ft of soil or other material which has a permeability of less than 1×10^{-7} cm/s lies between the lowest artificial liner or the lowest engineered soil liner and the uppermost regional aquifer (Ref. 1). The term artificial liner implies a synthetic liner, such as geomembrane.

  - State Regulation, Clause III: No less than 20 ft of naturally occurring material lies between the lowest artificial liner or the lowest engineered soil liner and the uppermost regional aquifer that would retard the migration of water containing the hazardous constituents in the waste to the same degree provided by 30 ft of material with a permeability of 1×10^{-7} cm/s (Ref. 1).

    For simplicity, this requirement is referred to hereafter as "the minimum 20-ft thickness requirement." In general, the naturally occurring materials at the site consist of loess, Ferrelview clay, clay till, basal till, and residuum. The state has agreed that naturally occurring materials may also include compacted engineered low-permeability earthfill materials.

- At the Weldon Spring site, the cell design will conform to the State's Clause III regulation by relying on a minimum thickness of 20 ft of naturally occurring materials. The equivalency will mainly rely on the permeability of the Ferrelview clay and clay till layers (Ref. 56). In areas where the total thickness of the in situ Ferrelview clay and clay till is less than 20 ft, the minimum 20-ft thickness requirement will be met by including the overlying loess and the underlying basal till and/or residuum layers. Based on the conceptual cell layout design, the total area where the Ferrelview clay and clay till thickness is less than 20 ft within the waste limit is approximately 12% of the total waste footprint area. The minimum thickness of Ferrelview clay and clay till at any point within these areas ranges from 12 ft on the northeast side to 17 ft on the southwest side.

- In other areas, excavation of foundation soils for cell optimization will be allowed, provided that at least a 20-ft thickness of in situ Ferrelview clay and clay till in the foundation is left in place.

5.2.2.4 Identification of Alternatives. Conceptual designs for two processes to treat selected contaminated materials are being developed in parallel: CSS and VIT. The VIT treatment process will produce less waste volume than the CSS process (Ref. 55). The cell siting design has considered both treatment alternatives. Since both alternatives require disposal of both treated and untreated radioactive wastes, a similar disposal cell configuration applies to both alternatives. Therefore, the CSS alternative has been used as the base case, while the VIT alternative has been treated as a modification to the base case reflecting a smaller cell.

An MVE approach, described in Section 3, was used to evaluate various alternatives for cell siting. Results of the MVE study (Ref. 57) are described below.

Because the disposal facility could not be sited until the number of cells had been determined, the MVE study (Ref. 57) first evaluated feasible alternatives for the number of cells. MVE Table 5.2.2-1 lists three alternatives and the evaluation criteria for selecting the number of cells for both the CSS and VIT cases: (1) a single cell, (2) two cells, and (3) more than two cells. Essentially, the selected alternative, as dictated by the criteria, shall:

- Enhance cell performance.
- Minimize worker radiation and chemical exposure.
- Incorporate the flexibility to adjust to changes in the volume of waste to be contained.
- Be easy to construct.
- Minimize the volume of construction materials required.

5.2.2.5 Evaluation of Alternatives. MVE Table 5.2.2-1 lists the advantages and disadvantages for each of the three alternatives considered.

The single-cell alternative has the most significant advantages compared to the other two alternatives. The single-cell concept is easier to design and construct, minimizes the volume of construction materials required, maximizes flexibility to adjust to waste volume changes during construction, and eliminates the complexity of constructing a number of cells concurrently. The main disadvantages of the single-cell alternative include increased worker radiation and chemical exposure, and an increase in the potential for differential settlements of the disposal cell due to the greater height of a single cell.

The two-cell alternative allows separate designs for separate waste types, i.e., one cell for treated (CSS or VIT) waste, the other for the remaining untreated materials. This alternative facilitates the use of different base elevations to best fit the existing topography, reduces worker radiation and chemical exposure, and allows more waste placement flexibility than the single-cell alternative. The main disadvantages are that the two-cell alternative occupies more area and requires more construction materials, a more complex design, especially regarding surface water control features, and more surveillance and maintenance. This alternative increases both the flow concentration from runoff between cells and the area of infiltration.

The more-than-two-cell alternative has essentially the same advantages and disadvantages as the two-cell alternative. The disadvantages, however, are considerably greater. In addition, the more-than-two-cell alternative may interfere with the sequencing of cell construction.

5.2.2.6 Selection of the Preferred Alternative. A single cell was selected as the preferred alternative for both the CSS and VIT waste treatment options. In addition to advantages discussed in Section 5.2.2.5, the single cell design will also allow for simpler surveillance, maintenance, and surface water control.

5.2.2.7 Details of the Preferred Alternative. A single cell will be designed to contain the site wastes. The cell designs for the CSS and VIT treatment options are similar; however, the footprint area of the cell for the VIT option is about two-thirds of the cell footprint area for the CSS option.

Based on the latest available site topography map, substrata soil isopach maps, and the proposed cell configuration (see Section 5.2.3), a cell footprint meeting the location and performance requirements, performance goals, restrictions, and considerations is illustrated in Figure 5.2.2-1. The proposed cell location has the following features:

- The cell is within the Weldon Spring site and generally within the site suitability area. The waste is within the site suitability area as shown in Figure 5.2.2-1.

- The toe line of an imaginary 3H:1V slope projected outward from the outermost limit of the waste is within the site suitability area and is at least 300 ft from the site boundary line at all locations (see Figures 5.2.2-1 and 5.2.2-2).

- Most of the area beneath the waste is underlain by at least 20 ft of Ferrelview clay and clay till soil strata, as shown in Figure 5.2.2-3. In areas where these soil layers are less than 20 ft thick, compacted low- permeability soil backfill will be used to meet the minimum 20-ft thickness requirement (see Section 5.2.4) with isolated exceptions as noted in Section 5.2.3.6.1.

- The cell toe line, including the temporary construction slope toe line, is at least 50 ft from most existing or proposed remedial operation facility features and will not interfere with the sequencing of the remedial operations:

  - The east and southeast waste limit lines are located so that the corresponding cell toe line will be at least 50 ft away from the existing administration building. It should be noted that the final cell toe line will be very close to the extension structure (laboratory) of the existing administration building. Therefore, the outside cell slope at that location will be temporarily made steeper in order to allow enough clearance for the construction road during cell construction. Near the end of the cell construction, the laboratory structure may be removed or relocated, if the laboratory function is not as critical. The outside cell slope will then be completed with the final 5H:1V slope.

  - The south waste limit is designed so that the south cell toe line will be at least 150 ft away from the site water treatment plant.

  - To accommodate an 80-ft to 100-ft-wide construction road near the northeast corners of Raffinate Pits 1 and 3 in the southwestern and western parts of the cell footprint, respectively, these parts of the cell footprint are set up so that the toe line of an imaginary 3H:1V slope will be located at least 80 ft away from the

raffinate pits to allow enough clearance for the construction road during cell construction.

5.2.2.8 Technical Uncertainties. MVE Table 5.2.2-2 documents the application and use of the observational method to possible modification of the cell location. MVE Table 5.2.2-3 lists the additional data needs identified for each area of uncertainty.

For the single-cell alternative, the cell will remain open until all designated waste is disposed of. The flexibility to accommodate disposal waste volume adjustments that might occur during the site cleanup is considered critical, because experience has demonstrated that it is extremely difficult to accurately estimate final waste volumes prior to actual cleanup. The potential deviation is the total volume of waste requiring disposal. This deviation need not affect the performance of a single disposal cell. However, a more accurate estimate of the total volume of waste will be required for Title II design. The final design of the cell layout and configuration, as well as waste placement procedures, shall be flexible enough to accommodate increase to the design volume of waste to be contained.

5.2.3 Cell Configuration/Optimization

Optimization of the cell configuration included the identification of possible disposal cell shapes, the cell height, the outline (profile) of the clean-fill dike side slopes (i.e., slope angles, berms, convex or concave surfaces), and the shape and location of individual cell components.

A single disposal cell constructed on site will contain all of the waste from the chemical plant site and the nearby quarry. The anticipated waste forms and estimated quantities requiring disposal are summarized in Section 6. Because the actual waste volumes will not be known until the disposal operation is nearly complete, the disposal cell design capacity includes a contingency factor of 50% above the current waste volume estimates. The contingency factor is based on experience gained during similar projects.

5.2.3.1 Functional Requirements. The functional requirements of the disposal cell are presented below:

- The design cell capacity must be 1.5 million cu yd for the CSS waste treatment option (Ref. 55) or 1.05 million cu yd for VIT waste treatment option (Ref. 55).

These design cell capacities include a 50% contingency factor applied to current waste volume estimates. The total waste volumes for the CSS and VIT treatment options cited in Section 6 are based on *Supporting Study No. 9A Waste Form Placement* (Ref. 58). These volumes are about 2.4% larger than the previous estimate for CSS treatment option (Ref. 55) and about 5.4% larger than the previous estimate for VIT treatment option (Ref. 55). However, these differences are not considered significant with regard to the 50% contingency factor and should not affect the current cell layout design. Volume estimates available at the time of final design will be used for Title II design, along with the contingency factor appropriate at that time.

- To enhance aesthetics and improve public perception, the cell height must be no more than 74 ft from the ground level around the cell toe line (Ref. 55).

- The cell footprint area increases as the waste thickness decreases for a given storage volume, resulting in increased costs for foundation grading, liner, and cover materials. Therefore, the waste thickness must be at least 20 ft (Ref. 55).

5.2.3.2 **Performance Requirements.** The disposal cell configuration must meet the following performance requirements:

- The cell will limit the migration of contaminants and provide effective control of waste for up to 1,000 years to the extent reasonably achievable and, in any case, for at least 200 years (Ref. 55).

- The cell will withstand the long-term and short-term design seismic loadings of 0.17 g and 0.13 g, respectively (Ref. 55).

- The conceptual design erosion protection features will withstand the design storm, which is the probable maximum precipitation (PMP) event (Ref. 55). The design storm is an open issue and the final design storm will be determined prior to or during Title II design.

5.2.3.3 **Identification of Alternatives.** The design considerations for cell configuration optimization consist of (1) variations in cell size, height, and shape (plan view and

profile); (2) containment of waste below or above grade; and (3) various waste encapsulation systems designs. To address these considerations, MVE studies were conducted (Ref. 59) to evaluate various alternatives for optimizing the cell configuration.

The following three cell configuration alternatives were evaluated for the first two considerations cited above:

- Excavate below grade (referred to as partially below grade) for waste encapsulation. The depth of excavation will be as deep as possible without violating the minimum 20-ft thickness requirement (See Section 5.2.2.3).

- Allow base plane of disposal cell to deviate from being parallel to site topography. (This approach mainly concerns the balance of cut and fill. However, the cut and fill volumes may be excessive.)

- Increase the cell area within the site suitability area established in the site suitability study (Ref. 16).

These alternatives are listed in MVE Table 5.2.3-1. The table also identifies the criteria used to evaluate the cell shape and cell footprint geometry. The criteria mainly require that the optimal cell geometry enhances slope stability, reduces cell settlement, reduces infiltration, reduces surface erosion from runoff, and provides the flexibility for waste volume adjustment.

For the third consideration cited above, MVE Table 5.2.3-1 lists two alternative perimeter waste encapsulation systems: the CFD and the no clean-fill dike (NCFD) alternatives. A CFD is a structure constructed of suitable soils around the perimeter of the disposal cell which, in conjunction with the cell cover, encapsulates the waste. Detailed discussions of the perimeter waste encapsulation systems are presented in Section 5.2.7.3. The criteria used to evaluate the two alternative waste perimeter systems are listed in the table. Essentially, the criteria dictate that the waste perimeter system design should enhance cell performance, increase erosion resistance, increase slope stability, facilitate leachate control, and reduce worker radiation and chemical exposure.

5.2.3.4 Evaluation of Alternatives. MVE Table 5.2.3-1 also lists the advantages and disadvantages of each cell configuration alternative relative to the other.

The excavate-below-grade (also called partially-below-grade) alternative has the most advantages. For a given area, this alternative increases storage capacity, requires the least volume of construction materials, provides a borrow source, enhances cell performance, and reduces cell height, resulting in reduced visual impact. On the other hand, this alternative may be more complicated to design and construct. However, these disadvantages are minor compared to the resulting benefits. It is therefore recommended that the cell be as far below grade as possible without violating the minimum 20-ft thickness requirement.

The alternative allowing the base plane of the disposal cell to deviate from being parallel to site topography has advantages similar to those of the partially below grade alternative, but to a lesser extent. This approach provides greater design and construction flexibility; it also facilitates the optimization of leachate collection and site drainage systems. Because the base plane does not follow the site topography, design and construction of this alternative would be more complex. Also, for a given area and cell height, the cell storage capacity will be less than that of the partially below grade alternative.

The alternative that proposes increasing the cell area within the site suitability area has the most disadvantages. This alternative increases infiltration potential, requires more construction materials and greater land use, and increases the potential for a complex cell geometry. The main advantages include allowing more flexibility for capacity adjustments during cell construction and reducing the required waste thickness. Reducing the waste thickness will, in turn, reduce settlement, enhance slope stability, and reduce visual impact. The waste thickness, however, will not be less than 20 ft as described in Section 5.2.3.1.

The CFD alternative yields good overall performance, reduces worker radiation and chemical exposure, provides an additional safety margin against damage from differential settlements, and provides a wide buffer between the cell surface and the contaminated material. However, this approach requires more construction materials and increases the cell footprint area, resulting in increased top cover area and riprapped sideslope surface to protect the CFD against erosion.

The no CFD alternative requires a smaller footprint area and less construction materials than the CFD alternative, but this alternative may also reduce cell performance and increase worker radiation and chemical exposure.

5.2.3.5 Selection of the Preferred Alternatives. The partially-below-grade alternative was selected as the preferred cell configuration because it minimizes cell height, thereby reducing the extent of sideslopes and increasing the storage capacity for a given area. The partially-below-grade cell configuration will be designed so that the cell foundation meets the minimum 20-ft thickness requirement. The preferred locations of the leachate collection sumps and a leachate retention basin are outside the disposal cell where the exit of leachate is daylighted, i.e., exposed without any deep excavation. To meet this daylighted requirement, which is not explicitly required by the State regulations, and to meet the cell foundation suitability requirement, the waste can only be placed partially below grade. Of the two conceptual cell layouts prepared for the below-grade alternative (see Section 5.2.3.6), the deeper excavation into the overburden soils is preferred. This preference is consistent with the previous alternative evaluation criteria listed in Table MVE 5.2.3-1.

The CFD was selected as the preferred perimeter encapsulation system based on its advantages, as discussed in Section 5.2.3.4.

5.2.3.6 Details of the Preferred Alternative. Design criteria and considerations used in the cell layout design are summarized below:

- Along a north-south direction, the southern existing ground surface is higher than the northern ground surface. To facilitate the longitudinal drainage of leachate to daylighted leachate collection sumps and the retention basin and to minimize the volume of excavation, the bottom of the cell foundation is sloped downward from south to north with the foundation slope equal to 1% on the southern half and 1.5% on the northern half.

- The location/extent of the north toe line is controlled by the leachate collection sumps and retention basin which will be daylighted about 300 ft from the site boundary line. The northern waste limit line of the CSS cell is located about 700 ft south of the north site boundary line.

- The designed cell bottom allows for a minimum thickness of 20 ft of overburden soils which in most cases consist of Ferrelview clay and clay till. However, in four localized areas, which comprise about 12% of the total waste footprint area, the in situ Ferrelview clay and clay till are less than 20 ft thick, even though the total

overburden soil thickness is more than 20 ft (see Figures 5.2.3-1 and 5.2.3-2). The minimum thickness of Ferrelview clay and clay till in these areas ranges from 12 ft to 17 ft.

- The waste thickness is at least 20 ft.
- The cell height is no more than 74 ft from the average ground level.
- The waste is surrounded by a clean-fill dike perimeter encapsulation system. The inside slope of the CFD is 3H:1V; the outside slope is 5H:1V.

5.2.3.6.1 CSS Cell. Based on the site topographic map and substrata isopach maps (Ref. 60), the minimum 20-ft thickness requirement, and the preferred cell configuration, two conceptual disposal cell layouts have been designed by optimizing the cell footprint area with the waste limit and cell toe line defined in Section 5.2.2.7. The first design is the upper-bound case with the minimum cell foundation excavation, and the second design is the lower-bound case with the cell foundation excavated to partially below grade (defined as the final grade just outside the disposal cell perimeter). The partially below grade configuration is also referred to as the deep excavation configuration in calculations.

The cell foundation in the upper-bound case has been designed to minimize the excavation depth by having a single plane surface, thereby minimizing the disturbance of the existing foundation soils, particularly the Ferrelview clay and clay till layers. The cell foundation in the lower-bound case, on the other hand, has been designed to maximize cell storage capacity by excavating cell foundation soils as deeply as possible without violating the minimum 20-ft thickness requirement. As shown in Figure 5.2.2-3, the total thickness of Ferrelview clay and clay till on the western side of the cell footprint is, in general, thicker than that of the eastern side of the cell footprint. The cell foundation with partially below grade configuration (lower-bound case) will be constructed at two elevations in an attempt to meet the minimum 20-ft thickness requirement, and to lower the cell foundation as much as possible to maximize the storage capacity with a minimum cell height. The western part of the cell foundation plane is 6 ft lower than the eastern part (which in turn is 4 ft lower than the cell foundation plane with the minimum excavation configuration for the upper-bound case). A transversal inclined plane with a slope of 12.5H:1V, covering a horizontal distance of 75 ft (a recommended distance for half drainage bay), connects the western and eastern planes.

Figures 5.2.3-1 and 5.2.3-2 show the conceptual foundation plans for the CSS cell with a minimum excavation configuration (upper-bound case) and a partially below grade (lower-bound case), respectively. As shown on these foundation plans, there are some localized areas along the northwestern, northeastern, southwestern and southeastern sides of the waste footprint with less than 20 ft of Ferrelview clay and clay till. The Ferrelview clay and clay till thickness is no less than 17 ft in the localized area on the southwest side, no less than 14 ft on the southeast side, no less than 16 ft on the northwest side and no less than 12 ft on the northeast side; the extent of these localized areas are about 1.4%, 4.8%, 3.1% and 2.4% of the total waste footprint area, respectively, for a total of approximately 12%. Despite the small sizes of these localized areas where the total Ferrelview clay and clay till thicknesses range from 12 ft to 17 ft, the requirement for a minimum thickness of 20 ft of naturally occurring materials will be fulfilled by including the underlying basal till and/or residuum layers for areas on the southwest, northwest and northeast sides. The total area involved is approximately 7%. On the southeast side area of approximately 5% of the total waste footprint, the deep excavations required for the removal contaminated soils in this area will be replaced by well compacted engineered low-permeability backfill.

Based on these foundation plans, the relationship between waste thickness and waste storage capacity for the minimum excavation and partially below grade configurations has been developed, as shown in Figure 5.2.3-3 (Ref. 61). Waste thickness, in this case, is defined as the thickness of waste placed between the bottom of the cell cover and the top of the basal liner and leachate collection system. As shown in Figure 5.2.3-3, for the CSS cell with a design volume of 1.55 million cu yd, the waste thickness is 26 ft for the minimum excavation configuration and 22 ft on the eastern half for the partially below grade configuration. However, for the partially below grade configuration, the foundation stratigraphy allows a deeper excavation on the western half of the cell, creating a waste thickness of 28 ft in this area. The resulting foundation level for the partially below grade configuration is 4 ft and 10 ft lower on the eastern half and on the western half, respectively, than that for the minimum excavation configuration.

The total cell thickness is defined as the thickness between the top of cell cover and cell foundation; therefore, it is equal to the sum of the thicknesses of a 10-ft-thick cell cover, the waste, and a 6.5-ft-thick basal liner and leachate collection system. The total cell thickness is calculated to be 43 ft for the minimum excavation configuration, and 39 ft and 45 ft for the partially below grade configuration. The average cell height is defined as the difference between

the elevation of the top of the 5H:1V slope and the average elevation of existing grade around the exterior toe of the CFD. As designed, the average cell height is 52 ft for the minimum excavation configuration and 43 ft for the partially below grade configuration, resulting in a difference of 9 ft in average cell height. While the final design may not include such a step in the foundation bottom, it is presented here to indicate the potential for maximizing excavation. Other considerations, such as differential settlement, may influence the steepness of such a step. Figure 5.2.3-4 illustrates the comparison of total cell thickness between the minimum excavation and partially below grade cell configurations, plotted against relative elevation. As shown in this figure, the top of the partially below grade cell is 8 ft lower than the top of the minimum excavation cell. The difference between the cell height (9 ft) and the top of cell elevation (8 ft) reflects a difference of 1 ft in the average toe elevation between the two configurations.

Figure 5.2.3-5 illustrates the details of the interface between the waste and the CFD and Figure 5.2.3-6 illustrates a typical geologic profile. As shown in Figure 5.2.3-5, the CFD configuration is optimized by moving the original projected interior slope outward to intersect a point on the waste limit line at half of the waste thickness. Such a CFD configuration would not only reduce the volume of CFD material, increase cell storage capacity, and reduce cell height, but also would allow a more durable transition zone from the top slope to the side slope of the cell. The exact configuration of the interface between the waste and the CFD will be determined in Title II design.

Based on the design cell height for each cell configuration for the CSS cell, a series of cross sections were prepared to illustrate the existing geologic profile and cut and fill operations required for each cell configuration. Figures 5.2.3-7 through 5.2.3-10 show the minimum excavation cell configuration at Sections L, M, N and O. Figures 5.2.3-11 through 5.2.3-14 show the partially below grade cell configuration at the same section locations. With the CFD configuration as shown in Figure 5.2.3-5, about 1.6 million cu yd of CFD general fill material will be required for the minimum excavation cell configuration and about 1.0 million cu yd are required for the partially below grade cell configuration (Ref. 59). Table 5.2.3-2 summarizes the waste storage capacity, waste thickness, cell thickness, and CFD general fill volume for each of the two cell configurations for the CSS cell. The foundation slope is 1% on the southern half and 1.5% on the northern half to account for long-term total settlement at the central area and to facilitate longitudinal drainage for the leachate collection and removal system, which is daylighted at the northern end of the cell. These features are shown in Figure 5.2.3-1 and

Figure 5.2.3-10 for the minimum excavation configuration and in Figures 5.2.3-2 and 5.2.3-14 for the partially below grade cell configuration.

A plan view of the completed CSS cell, based on the design cell height for the minimum excavation configuration and partially below grade configuration, respectively, is shown in Figures 5.8.3-15 and 5.8.3-16.

5.2.3.6.2 VIT Cell. Conceptual foundation plans for the VIT cell with the minimum excavation configuration and the partially below grade configuration are shown in Figures 5.2.3-17 and 5.2.3-18, respectively. The VIT cell foundation plans are essentially the same as those for the CSS cell, with the exception of a smaller footprint area. The VIT cell layout design is primarily based on using the same cell height as the CSS cell and reducing the footprint area to account for the design VIT cell capacity of 1.05 million cu yd, which is 0.5 million cu yd less than the CSS cell capacity. With the modified CFD configuration (as described for the CSS cell), about 1.32 million cu yd of CFD material are required for the minimum excavation cell configuration, and about 0.78 million cu yd of CFD material are required for the partially below grade cell configuration (Ref. 61). Table 5.2.3-2 summarizes the waste storage volume, waste thickness, cell thickness, and CFD general fill volume for the two cell configurations. Figures 5.2.3-19 and 5.2.3-20 show the plan views of the minimum excavation cell configuration and the partially below grade cell configuration, respectively.

5.2.3.7 Technical Uncertainties. Table 5.2.3-3 documents the application of the observational method to cell configuration optimization. Table 5.2.3-4 lists additional data required to assess each technical uncertainty. A potential deviation affecting cell configuration optimization is that a portion of the footprint area may not meet the minimum 20-ft thickness requirement. Details of this technical uncertainty are discussed in Section 5.2.4.7.

5.2.4 Foundation

For design purposes, the disposal facility foundation will include the area 50 ft outside the toe of the CFD. The foundation material underlying the proposed disposal cell consists of 25 ft to 56 ft of overburden soil, underlain by a 10-ft to 50-ft-thick layer of weathered rock over competent bedrock (limestone). The overburden soil is composed of glacial and preglacial deposits capped by a thin layer of organic topsoil and scattered areas of existing fill consisting of clayey silt to silty clay about 5 ft in thickness. As shown in Figure 5.2.3-6, the soils

underlying the Topsoil/Fill unit consist of, in descending order, loess, Ferrelview clay, clay till, Basal Till, and Residuum. In general, the soils are relatively uniform and consist predominantly of yellowish brown, firm to very stiff silty clay to clayey silt with minor to some sand and gravel content.

The geologic suitability of the site is discussed in several supporting documents that address geology (Ref. 18), seismicity (Ref. 19), and geomorphology (in progress by the PMC). Therefore, geologic suitability is not discussed further. Suitability of the soil and bedrock units as a foundation for the proposed disposal cell, in terms of permeability and collapse potential, is discussed in the site suitability study (Ref. 16).

5.2.4.1 Functional Requirements. The function of the foundation is to provide a clean (uncontaminated), clear (of debris, vegetation, roots, and organic materials), and firm base for the placement of a perimeter CFD and a liner system for the disposal cell. The disposal cell foundation must provide sufficient support to ensure that the disposal cell remains stable under the design loading conditions, and that settlements are limited to amounts insufficient to cause distress of the disposal cell. In addition, the foundation must be of sufficiently low permeability, as required by State regulations, to retard the downward movement of moisture toward the groundwater table.

5.2.4.2 Performance Requirements. The operations necessary to ensure the proper preparation of the foundation material are discussed in Section 6.2.3. The performance requirements necessary to meet the other functional requirements are described below.

- The minimum factors of safety required for the disposal cell slopes to ensure stability are:

  - Short-term and long-term static: 1.3 and 1.5, respectively (Ref. 51).
  - Short-term and long-term seismic: 1.0 for both conditions (Ref. 51).

- Anticipated differential settlements of the prepared foundation due to the disposal cell loading will not cause ponding in the top slope. Tensile strains on the radon barrier and other low-permeability layers of the cover and liner systems caused by differential settlements in the foundation will not cause these materials to crack.

- Technically, a low-permeability foundation is not required if the disposal cell functions as planned. Even in the absence of a low-permeability foundation, there are a considerable number of redundant features within the disposal cell that will limit or prevent the migration of contaminants from the cell into the foundation. However, additional protection against contaminant migration can be achieved by meeting the criteria cited in the Missouri State Regulations regarding hazardous waste facility siting (10 CSR 25-7), as presented in Section 5.2.2.3. At the site, equivalency with state guidelines is achieved by having 20 ft of naturally occurring materials composed mainly of low-permeability soils such as the Ferrelview clay and clay till, and including other soil layers such as loess and basal till. There is about 7% of the total waste footprint area requiring the inclusion of loess and basal till layers in order to meet the minimum 20-ft thickness requirement. The minimum Ferrelview clay and clay till thickness in these areas ranges from 12 ft to 17 ft. In limited locations of deep excavations, about 4.8% of the total waste footprint area, the excavated naturally occurring materials will be replaced with well compacted engineered low-permeability backfill to meet the equivalency requirement.

5.2.4.3 **Identification of Alternatives.** Analyses indicate that, with proper foundation preparation, adequate stability and settlement characteristics can be achieved. The existing cell foundation can be designed so that all functional and performance requirements are met. If the characteristics and permeabilities of the Ferrelview clay and clay till do not meet the minimum 20-ft thickness requirement, the cell foundation will be amended. Five cell foundation design alternatives for improving the permeability of the foundation were evaluated (Ref. 59). As listed in MVE Table 5.2.4-1, the five cell foundation design alternatives are:

- Remove and replace: Part or all of the foundation materials are removed and replaced with select well compacted low-permeability materials to lower the equivalent permeability characteristics of the foundation.

- Remove and amend: Part or all of the foundation materials are removed and replaced with well compacted soils mixed with appropriate proportion of admixtures to improve the overall foundation permeability and geochemical attenuation properties.

- Raise grade: Additional select, well compacted materials are placed on top of the existing ground level to increase the distance to groundwater table and to decrease the overall equivalent permeability characteristics of the foundation soils.

- At grade: Cell foundation is essentially placed at existing ground surface (level) by minimizing grading (cut and fill) operations.

- In situ stabilization: In situ foundation soils are mixed, if feasible, with injected or pumped chemical grout in order to stabilize the foundation soils and improve their physical (such as permeability and strength) and geochemical attenuation properties.

Contaminated or otherwise unsuitable soils, abandoned building foundations, and underground utilities exist within the proposed cell foundation footprint. Therefore, these unsuitable materials will be removed and replaced with select compacted fill as part of the foundation preparation requirements for all the above cell foundation design alternatives.

5.2.4.4 Evaluation of Alternatives. MVE Table 5.2.4-1 lists the evaluation criteria and the advantages and disadvantages of each cell foundation design alternative if the minimum 20-ft thickness requirement cannot be easily met with the existing foundation condition. As shown in the table, major evaluation criteria (with weighing factors in decreasing order), include protection of groundwater, compliance with regulations, capability of supporting the disposal cell, and performance.

Performance can be easily demonstrated for the remove-and-replace design alternative by controlling the engineered material properties, and this alternative complies with the State's Clause III regulation (see Section 5.2.2.2). Major disadvantages include more complex foundation and leachate collection system designs and construction, extensive field and laboratory data requirements to demonstrate the performance of the foundation, significant environmental impacts due to borrow material requirement, and high costs.

The remove-and-amend design alternative has advantages and disadvantages similar to the remove-and-replace design alternative; however, environmental impacts are less, because less off-site borrow material is required. Furthermore, mixing the soil with different materials is difficult and more costly.

The raise-grade design would provide a thickness of controlled fill above the existing grade. Design and construction of the disposal cell including the liner and leachate collection system, are simpler, and this alternative more easily complies with the State's Clause II or III regulation (see Section 5.2.2.2) because of the engineered fill. However, construction costs would be very high because of the large volume of additional fill material required. In particular, raising the grade would result in added volume of CFD.

For the at-grade design alternative, design and construction of the disposal cell, including the liner and leachate collection system, are easier, and this alternative complies with the State's Clause III regulation (see Section 5.2.2.2). However, it may be more difficult to demonstrate foundation performance than for the other alternatives.

In situ stabilization would entail of in-place mixing of the foundation soils with a chemical grout. Design and construction of this alternative are relatively simple. However, difficulties may be encountered while mixing the different materials, and performance is difficult to demonstrate.

5.2.4.5 Selection of Preferred Alternative. The remove-and-replace design alternative for foundation amendment is preferred, if the minimum 20-ft thickness requirement cannot be achieved by the Ferrelview clay and clay till. This alternative requires that a portion of the upper part of the foundation soil be excavated, placed back, and recompacted to a recommended degree of compaction and moisture content to reduce the overall foundation permeability. Thus, the upper recompacted foundation layer of low permeability can be included in the minimum 20 ft of Ferrelview clay and clay till layers (equivalent to 30 ft of foundation soil with a permeability of less than 1×10^{-7} cm/sec). For conceptual design, a minimum thickness of 5 ft of excavated and recompacted foundation layer has been assumed.

5.2.4.6 Details of Preferred Alternative. This section discusses general requirements for disposal cell foundation preparation in addition to the requirements associated with the preferred cell foundation design alternative.

5.2.4.6.1 CSS Cell. Locations and depths of existing contaminated soil within the disposal cell footprint are detailed in Section 5.1.2. In addition, all soils within a depth of 2 ft beneath abandoned building foundations and sumps, and around underground utilities are assumed to be contaminated or otherwise unsuitable, and therefore should be removed. For

conceptual design, a 2-ft x 2-ft area around the underground utilities is considered contaminated and has been designated for excavation and removal. Any soil outside the unsuitable/ contaminated surface is considered to be clean.

Details of excavation requirements are discussed in Section 6.2.3.2. Excavated materials, if uncontaminated and determined to be suitable in terms of material type and quality by a competent field engineer, will be used as backfill for CFD foundation grading or as fill for the CFD construction. The required material properties of the foundation backfill and the CFD are described in Section 5.1.7.1.

Based on the cell layout design and cell configuration design, detailed in Sections 5.2.2 and 5.2.3, respectively, and the cell foundation plan shown in Figure 5.2.3-2, the preferred cell foundation will be partially below grade.

5.2.4.6.2 VIT Cell. In general, the above general requirements for the CSS cell foundation preparation also apply to the VIT cell. Because of the smaller footprint area, the excavation quantity due to foundation grading requirements, in addition to the excavation quantities of clean and contaminated soils discussed above, will be less.

5.2.4.6.3 Settlement and Slope Stability. With a loading of a 45-ft-thick disposal cell, the predicted maximum long-term total settlement of the cell foundation was calculated to be about 2 ft at the central area of the disposal cell. Long-term differential settlements between adjacent localized areas, such as areas between in situ foundation soil and backfill of deep trenches and between the east and west halves of the cell (see Figure 5.2.3-2), were found to be insignificant and thus, should have no effect on the cell foundation performance.

As shown in the disposal cell foundation plan (Figure 5.2.3-2) and the disposal cell configuration (Figure 5.2.3-14), a 1.5% foundation slope on the northern half is designed to account for long-term total settlement of 2 ft at the central area. This design will provide a minimum 1% foundation slope for longitudinal drainage of the LCRS between the central area and the northern area even after total settlement. Similarly, due to the layer settlements in the central area, the slope from the south end to the central area will be greater than the designed 1%.

The disposal cell design using the above geometries and layouts will have factors of safety against slope failure that exceed the minimum values discussed in Section 5.2.4.2 for all design loading conditions.

5.2.4.7 **Technical Uncertainties.** One major technical uncertainty is the extent and depth of contaminated soils, particularly those surrounding underground utilities and sewers of abandoned buildings within the disposal cell footprint, and around the northeast corner of Raffinate Pit 3 where some seepage was encountered at the dike. The extent and depths of contaminated soils within the cell footprint will be verified prior to or during final (Title II) design and will be more accurately determined during the construction of the cell foundation.

Another technical uncertainty is whether the Ferrelview clay and clay till beneath the disposal cell footprint meet the minimum 20 ft thickness requirement. Field verification that these units satisfy the equivalent permeability requirement is also necessary. Previous laboratory permeability test results (Ref. 18) and the ongoing *Supporting Study 3A – Hydraulic Parameters of Undisturbed Soil* (Ref. 62) are expected to substantiate compliance with the equivalent permeability requirement by both laboratory and field permeability test results. In areas where the minimum 20 ft thickness and equivalent permeability requirements are not met, the technical uncertainties will be mitigated by replacing well compacted engineered low-permeability fill materials. In addition, the upper recompacted foundation layer of low-permeability materials may also be used as a geochemical barrier, a zone that functions as an adsorption medium to attenuate or retard the spread of chemical contamination. An ongoing study by Pacific Northwest Laboratories will address the possible use of this layer as a potential contingency for this function during Title II design. As shown on the foundation plan and cross sections in Figures 5.2.3-2, and 5.2.3-11 through 5.2.3-13 for the CSS cell with a partially below grade configuration, there are two localized areas on the western side and one area on the northeastern side of the cell footprint with less than 20 ft of in situ Ferrelview clay and clay till within which the cell base is founded. The total area of these localized areas is about 7% of the total waste footprint area, and the minimum Ferrelview clay and clay till thickness ranges from 12 ft to 17 ft. However, based on the initial laboratory and field permeability test results presented for ongoing *Supporting Study 3A* (Ref. 62), the required equivalent permeability per State Clause III can be achieved by less than 15 ft of thickness of Ferrelview clay and clay till. Therefore, by including the underlying basal till and/or residuum layers, the minimum 20-ft thickness requirement of naturally occurring materials can be met. The total thickness of overburden soils from Ferrelview Clay to the top of bedrock within the cell footprint is greater than 20 ft.

5.2.4.8 **Specifications.** The specifications required for foundation preparation are listed below:

- Site clearing.
- Waste removal.
- Earthwork.

5.2.5 Liner and Leachate Collection and Removal Systems

5.2.5.1 **General.** The liner system is a combination of liners (physical barriers) and LCRS. A liner is a physical barrier composed of one or more individual barriers (components). A liner composed of multiple components is a composite liner. The LCRS collects and removes leachate from the disposal cell. Due to the complexity of the liner system, the liners are specifically addressed in Section 5.2.5.2 and the leachate collection and removal system is addressed in Section 5.2.5.3.

5.2.5.1.1 **Functional Requirements.** The liner system will cover the bottom of the disposal facility and the interior slopes of the perimeter CFD. In a below-grade disposal facility, the liner system will also cover the excavation side walls. In a partially below-grade disposal facility, the liner system will cover a combination of the above. The short-term functional requirements of the liner system are to contain and collect transient leachate and to allow monitoring of the leachate quantity and quality. The long-term functional requirements are to allow equilibrium flow from the cell bottom, provide added retention and attenuation of leachate constituents, and allow monitoring of leachate quality.

5.2.5.1.2 **Performance Requirements.** The general performance requirements of the liner system are to minimize the need for maintenance and monitoring of the system itself, incorporate feature redundancy, consider the benefit and cost ratio, and minimize the potential for system failure. The liner system should be chemically compatible with the waste and leachate. It should withstand any potential pressure gradients, climatic stresses, installation and operation stresses, mechanical stresses, and comply with all identified and potential applicable and/or relevant and appropriate requirements (ARARs).

5.2.5.1.3 Identification of Alternatives. The alternatives evaluated for the liner system design are:

- No liner and no LCRS.
- Single liner, without LCRS.
- Single liner with LCRS.
- Double liner with two LCRSs.
- More than two liners with more than two LCRSs.

5.2.5.1.4 Evaluation of Alternatives. MVE Table 5.2.5-1 lists the advantages and disadvantages of each of the liner system alternatives. The evaluation criteria, which are the functional and performance requirements, are also listed in the table. Each alternative consists of some combination of liners and leachate collection and removal systems in numbers varying from 0 to 3 or more. The liner provides leachate containment. The leachate collection and removal system, in conjunction with the liner, collects and removes leachate. Without a leachate collection and removal system, ponding on the liner will occur. However, a leachate collection and removal system may require monitoring and maintenance. The evaluation criteria selected include RCRA criteria for sanitary and hazardous waste landfill liners and leachate collection and removal systems, as well as site-specific criteria.

5.2.5.1.5 Selection of the Preferred Alternative. A double-liner system with two leachate collection and removal systems is the preferred alternative for the disposal facility liner system. This liner system will perform well over both short and long term. It will allow detection of leaks through the primary liner by means of the redundant leachate collection and removal system. This redundant design eliminates the need for repairs (which would be impossible to perform), if failure of the primary liner and/or leachate collection and removal system occurs. The double-liner system is the most cost-effective means of preventing leachate from exiting the disposal facility.

5.2.5.1.6 Details of the Preferred Alternatives. The double-liner system is composed of multiple components. Figure 5.2.5-1 illustrates a schematic plan and section of the liner system for the CSS treatment option. Figure 5.2.5-2 illustrates the plan and section for the VIT treatment option. Figure 5.2.5-3 details the individual components and their sequencing. Each component is the selected preferred alternative from various possible design alternatives. In descending order, the liner system components are:

- Leachate Collection and Removal System
- Primary Composite Liner:
  - Flexible membrane liner (FML)
  - Geosynthetic clay liner (GCL)
- Redundant Leachate Collection and Removal System
- Secondary Composite Liner:
  - Flexible membrane liner
  - Compacted clay liner (CCL)

Details and discussions of the composite liners are presented in Section 5.2.5.2. Details of the leachate collection and removal systems are included in Section 5.2.5.3.

5.2.5.1.7 **Technical Uncertainties.** Technical uncertainties were evaluated by the observational method and are listed in MVE Table 5.2.5-2. An uncertainty of concern is the long-term leachate flow rate. The disposal cell performance assessment discussed in Section 8 provides data on leachate flow rates. Geosynthetic longevity is also uncertain due to the relatively recent development of geosynthetics. However, accelerated testing and extrapolation of existing data indicate probable longevity on the order of hundreds of years (Ref. 63).

A leak detection system is currently being considered for the disposal cell cover. If it can be demonstrated that a cover leak detection system can function effectively, then the redundant LCRS from the bottom liner can be eliminated, provided the disposal cell performance assessment predicts no leachate generation. The results of the groundwater studies will also impact this decision. If regulators require clear separation of the disposal cell and groundwater, then a redundant LCRS is required to verify performance of the primary liner and LCRS. Without the (redundant) LCRS, the performance of the primary liner and LCRS cannot be assessed. Further discussion is found in Section 5.2.5.1.8.

If the long-term leachate constituent concentrations are expected to be greater than the level acceptable for direct surface or subsurface release, a geochemical barrier design contingency may be required. Such a geochemical barrier would adsorb, absorb, or otherwise attenuate the leachate constituents of concern. The barrier could be placed in the flowpath of leachate exiting the disposal facility and designed to function as a passive control measure.

Possible locations include between the waste and the LCRS, below the liner system, or outside of the disposal facility perimeter in a zone through which leachate would percolate.

5.2.5.1.8 **Performance of Components.** The double-liner system with primary and redundant leachate collection and removal systems will meet or exceed the functional and performance requirements for the liner system. This system will prevent the leachate from becoming mixed with the existing contaminated site groundwater. The liner system will also allow monitoring of the disposal facility performance without having to rely on monitoring wells in the previously contaminated aquifer. Leachate will be prevented from escaping the disposal facility during the short-term, nonsteady-state conditions. The natural components of the system will not degrade during the design life of the disposal facility and will allow the very small long-term, steady-state flows to pass through.

The redundant LCRS (along with the secondary composite liner) provides a mechanism for monitoring gross failure of the primary liner. The redundant LCRS also maintains the separation of disposal facility contaminants and existing groundwater contamination. Finally, if leaks in the primary liner occur and are detected in the redundant LCRS, data will be available that will allow a reassessment of the disposal facility performance.

5.2.5.1.9 **Design Criteria.** The design criteria for the liner system were developed in a design basis memorandum (Ref. 64) and are listed below:

1. Use natural materials to the extent possible to maximize longevity.

2. Implement stringent construction quality assurance and quality control procedures.

3. Incorporate lessons learned from the quarry staging ponds and equalization basin liners, specifically:

   - Manufacturer's procedures for liner installation must be followed.

   - The piping system between liner system and leachate holding facilities should be tested for system integrity.

   - Consider a variety of lining materials.

- Implement a documented construction inspection program.

The applicable codes and standards are:

- DOE Order 6430.1A
- Occupational Safety and Health Administration
- American Society for Testing and Materials
- American National Standards Institute (ANSI)
- National Sanitary Foundation (NSF)
- WSSRAP Project Procedures (including NQA-1 requirements)
- 40 CFR 264
- 10 CSR 25-7.264

5.2.5.1.10 Specifications. Because the liner system is composed of liners and leachate collection and removal systems, the specifications listed under Sections 5.2.5.2 and 5.2.5.3 are required.

5.2.5.2 Liner Components and Configurations. This section addresses the liners, their components, and their configurations.

5.2.5.2.1 Functional Requirements. A liner is a physical barrier that will cover the bottom of the disposal facility and the interior slope of the perimeter CFD. In a below-grade disposal facility, the liner will also cover the excavation side walls. In a partially below-grade disposal facility, the liner will cover all of the above. The short-term functional requirement of the liner is to contain transient (nonsteady-state) leachate and prevent uncontrolled exit of leachate from the disposal facility. The long-term functional requirements are to allow equilibrium flow from the bottom of the disposal facility and to provide added retention and attenuation of leachate constituents.

5.2.5.2.2 Performance Requirements. The general performance requirements of a liner are to be maintenance free, to incorporate redundancy, to optimize the benefit and cost ratio, and minimize the potential for liner failure. The liner should be chemically compatible with the waste and leachate. It should withstand any potential pressure gradients, climatic stresses, installation and operation stresses, mechanical stresses, and should comply with all

identified and potential ARARs. The liner should occupy a minimum volume within the disposal facility.

5.2.5.2.3 Identification of Alternatives. The alternatives evaluated for the liner design included both common and uncommon liner materials. Common liner materials were evaluated singly and in various combinations and configurations as composite liners. The alternatives evaluated are:

- FML
- CCL
- GCL
- FML/CCL composite liner
- FML/GCL composite liner
- FML/GCL/FML composite liner
- FML/GCL/CCL composite liner
- FML/CCL/FML composite liner
- Gravel
- Bitumen (asphalt)
- Portland cement concrete
- Epoxy sealant
- No liner
- Grouted soil
- Chemically amended soil
- Steel plates

5.2.5.2.4 Evaluation of Alternatives. MVE Table 5.2.5-3 lists the advantages and disadvantages of each of the liner alternatives. The evaluation criteria are also listed in the table.

5.2.5.2.5 Selection of the Preferred Alternatives. The preferred alternative for the liner components and configurations is a composite liner. The FML/CCL and FML/GCL alternatives are considered equal based upon benefit and cost ratios.

The advantage of the FML/CCL alternative is that it is capable of chemical absorption, adsorption, or attenuation. Therefore, the preferred alternative is for the secondary composite

liner to be placed on the bottom of the disposal facility, on the interior slope of the perimeter CFD, and/or on the excavation side walls.

The advantages of the FML/GCL alternative are that it occupies minimal space within the disposal facility and is easy to construct on top of geosynthetic materials placed on the interior slope of the perimeter CFD (or excavation side walls). Therefore, the FML/GCL alternative is the primary composite liner for the bottom of the disposal facility, the perimeter CFD interior slope, and/or the excavation side walls. 40 CFR 264.301(c) states that the lower component of the composite bottom line must be constructed of at least 3 ft of compacted soil material with a hydraulic conductivity of no more than 1 X 10^{-7} cm/sec.

5.2.5.2.6 Details of the Preferred Alternatives. Composite liners with FMLs and natural material components are recommended for both the primary and secondary liners. Composite liners are the state-of-the-art means of minimizing flow through liners.

The FML/GCL primary composite liner configuration provides a major line of defense in preventing leachate from passing through the bottom of the disposal facility. The GCL within the primary composite liner on the interior slope and/or excavation side wall is a manufactured bentonite blanket such as Claymax®, Bentomat®, Gundseal® or Bentofix®. The geosynthetic clay liner is capable of sealing leaks should the FML be punctured. Detailed discussion of the GCL is in Section 5.2.5.2.12.

Identical FMLs are recommended for both the primary and secondary composite liners. Details of the FML material type are in Section 5.2.5.2.11.

The secondary composite liner configuration is FML/CCL. The compacted clay liner will not only provide some degree of leak sealing capability in case the secondary FML is punctured, but will also adsorb, absorb, or otherwise attenuate many of the heavy metals and radionuclides which may be present in the leachate. The recommended thickness and other details of the compacted clay liner portion of the secondary composite liner are presented in Section 5.2.5.2.12.

The FML in the primary composite liner will be extended from the interior slope of the perimeter CFD up over the top of the waste to meet the cover FML. The FML in the primary composite liner will be seamed to the cover FML to provide total encapsulation of the waste.

Figures 5.2.5-1 and 5.2.5-2 illustrate this concept for CSS and VIT treatment options respectively. The GCL in the primary composite liner will not be extended over top of the waste.

5.2.5.2.7 Technical Uncertainties. Technical uncertainties are evaluated using the observational method and the results are listed in MVE Table 5.2.5-4. MVE Table 5.2.5-5 lists specific data quality objectives. FML longevity is uncertain due to the relatively recent development of geosynthetics. Accelerated testing and extrapolation of existing data indicate probable longevity on the order of hundreds of years.

5.2.5.2.8 Performance of Components. The composite liners will meet the functional and performance requirements identified above. During short-term conditions, the composite liners will contain transient leachate and prevent uncontrolled exit of leachate from the disposal facility. However, the FMLs are assumed to eventually degrade and cease to function.

The natural material components of the liners will not degrade during the design life of the disposal facility and will allow the very small long-term, steady-state flows to pass through. Maintenance is not required, and the possibility of catastrophic liner failure is considered remote.

5.2.5.2.9 Design Criteria. The design criteria for the liners were developed in a design basis memorandum (Ref. 64) and are listed below:

1. Use natural materials to the extent possible to maximize longevity.

2. Implement stringent construction quality assurance and quality control procedures.

3. FML seams should be testable.

4. Incorporate lessons learned from the installation of the quarry staging ponds and equalization basin liners.

The applicable codes and standards are:

- DOE Order 6430.1A.
- Occupational Safety and Health Administration.
- American Society for Testing and Materials.
- American National Standards Institute.
- National Sanitary Foundation.
- WSSRAP Project Procedures (including NQA-1 requirements).
- 40 CFR 264
- 10 CSR 25-7.264

5.2.5.2.10 Specifications. Specifications for the following major topics will be detailed:

- Earthwork.
- Flexible membrane liners.
- Geosynthetic clay liners.

5.2.5.2.11 Flexible Membrane Liners. This section addresses the FML portion of the composite liners. The natural material liner portion of the composite liner is addressed in Section 5.2.5.2.12.

Functional Requirement

The function of the flexible FML is to reduce leachate flow through the composite liners to an absolute minimum, or as low as reasonably achievable (ALARA), by acting as an essentially impermeable barrier.

Performance Requirements

The performance requirements of the FMLs are to withstand physical stresses anticipated during the construction period and to resist chemical degradation by the leachate. The FMLs should have a predicted design life, based upon extrapolated or accelerated testing results, that is on the order of hundreds of years. The FML field seams should permit nondestructive testing.

Identification of Alternatives

Alternative materials evaluated for the FML are:

- Smooth high-density polyethylene (HDPE).
- Textured high-density polyethylene.
- Polyvinyl chloride (PVC).
- Scrim-reinforced chlorosulfonated polyethylene (CSPE).
- Smooth very-low-density polyethylene (VLDPE).
- Textured very-low-density polyethylene.

Evaluation of Alternatives

The MVE approach was used in the evaluation process. MVE Table 5.2.5-6 lists the advantages and disadvantages of each of the alternatives considered. Also listed are the criteria used in the evaluation process. However, the evaluation cannot be completed until the results of the liner compatibility testing become available. The results will be used to compare the abilities of the various alternative material types to withstand chemical degradation by the leachate.

Selection of the Preferred Alternative

The preferred alternative for the FML material type cannot be determined until the liner compatibility test results become available. While all of the alternative material types have extremely low permeability, it appears now most likely that HDPE or VLDPE is the preferred material type based primarily upon cost, ability to resist chemical degradation, and availability with textured surfaces. A design thickness of 80 mils, along with textured surfaces, is recommended. If PVC or CSPE is determined to be the preferred material type through the compatibility testing, the design thickness may be different.

Details of the Preferred Alternative

HDPE has excellent chemical resistance, comparable longevity, and adequate strength. It is relatively inexpensive. However, HDPE can experience high thermal expansion and contraction prior to burial. VLDPE not only has properties similar to those of HDPE, but also

possesses excellent elongation and puncture-resistance properties. VLDPE is less resistant to chemical degradation than HDPE (Ref. 63 and Ref. 55). Both materials can be manufactured with textured surfaces that yield excellent interface friction between the FML and adjacent soils or geotextiles.

Both HDPE and VLDPE are seamed by welding with special equipment. Seams welded with a double-wedge welder can be pressure tested. However, HDPE and VLDPE may exhibit some degree of stress cracking near the seams (Ref. 55).

Technical Uncertainties

Technical uncertainties were evaluated using the observational method and are listed in MVE Table 5.2.5-7. The uncertain longevity of the FMLs is discussed as one of the technical uncertainties of the composite liners in Section 5.2.5.2.7.

Performance of Components

The FMLs will meet the functional and performance requirements outlined above. The FMLs are designed as part of the composite liners. Therefore, the overall composite liner performance described in Section 5.2.5.2.8 is the critical consideration rather than the FML performance alone.

Design Criteria

The design criteria, applicable codes, and standards for the FMLs were developed in a design basis memorandum (Ref. 64) and are listed in Section 5.2.5.2.9.

Specifications

- Flexible Membrane Liners

5.2.5.2.12 Natural Material Liners. This section covers the portion of the composite liners which is constructed of natural materials. The flexible membrane liner portion of the composite liner is discussed in Section 5.2.5.2.11.

Functional Requirements

The basic function of the natural material liner component is to act as a low-permeability hydraulic barrier that is sufficiently thick and water tight to prevent migration of any hazardous constituents through the liner to the adjacent native soils or groundwater during the active life and post-closure period (Ref. 65). Additionally, the liner may also act as a geochemical barrier to attenuate or retard the transmission of contaminants, either by chemical, physical, or ion exchange adsorption.

Performance Requirements

The liner, in this case the low-permeable layer or layers consisting of natural materials such as clayey soils with or without admixtures such as bentonite or GCL, will perform satisfactorily for at least 1,000 years to the extent reasonably achievable, and at any rate, for 200 years (Ref. 55). To perform satisfactorily for such a period, the liner will remain intact (uncracked), stable, and functional under long-term total and differential settlements of the foundation and under static and seismic loading conditions. To prevent cracking of the liner due to long-term differential settlements, the liner material will be carefully selected, engineered, and constructed. The liner must have a saturated hydraulic conductivity of 1×10^{-7} cm/s or less at all times for all cases.

Identification of Alternatives

It is assumed that at least one component of the foundation liner system selected for the WSSRAP disposal facility must be constructed of natural material with permeability of less than 1×10^{-7} cm/s (Ref. 65). The natural material liner will be placed underneath an FML as the lower component of a composite liner. Three liner alternatives were evaluated.

- Compacted clay liner: Minimum 3 ft thick liner constructed by compacting natural low-permeability materials (clayey materials).

- Geosynthetic clay liner: A manufactured liner consisting of a thin layer of clay sandwiched between two geotextiles or glued to a geomembrane, such as Bentofix®, Bentomat®, Claymax®, and Gundseal®.

- Compacted bentonite amended soil liner: Minimum 3 ft thick liner constructed by compacting soil (of any type) mixed with an appropriate proportion of bentonite.

Evaluation of Alternatives

An MVE approach was used to evaluate the foundation liner alternatives. MVE Table 5.2.5-8 lists the evaluation criteria as well as the advantages and disadvantages of each foundation liner alternative. As shown in MVE Table 5.2.5-8, the major evaluation criteria with weighting factors in decreasing order are ease of obtaining agreements with government agencies, chemical compatibility, permeability, ductility and public perception.

If a layer of compacted clay liner is used for the foundation liner, it will be easier to obtain agreements with government agencies and public acceptance. Due to its thickness, the liner is essentially immune to puncture and has leachate-attenuation capacity that allows it to function as a geochemical barrier. Because of its thickness, the liner takes up more space, can be relatively difficult to build uniformly, slows construction, and can cost more than other alternatives, depending upon the availability of suitable materials.

A compacted bentonite amended soil liner may be used for the foundation liner to improve the liner permeability requirement, if suitable materials are not easily available. This liner has many of the same advantages and disadvantages as the compacted clay liner. Additionally, mixing the soil uniformly with bentonite is difficult, and bentonite is expensive. Extensive dust control measures are often required during the mixing process, further increasing costs.

A geosynthetic clay liner would provide the low permeability required for the foundation liner. This liner is a thin manufactured product, takes up little space, and is relatively easy and fast to install. However, it is easier to damage and puncture. If this liner is used alone it is very difficult to establish its reliability to function as desired for the required performance period. Therefore, it may be difficult to obtain approval by government agencies and acceptance by the public; nevertheless, several RCRA sites using GCLs have received permits.

Selection of the Preferred Alternative

Based on the results of the MVE study, the following foundation liner alternatives are recommended in the order of preference:

- Alternative A – Compacted clay liner.
- Alternative B – Compacted bentonite amended soil liner.
- Alternative C – Geosynthetic clay liner.

Detailed recommendations for Alternative A are discussed in the following section. If, however, achieving the required hydraulic conductivity is found to be too difficult for this alternative (demonstrated test results for a test fill made of potential borrow materials at specified compaction efforts), Alternative B will be considered.

Depending on the type of mixing soil, more than 5% of bentonite should be used in the soil mixture in Alternative B to achieve the hydraulic conductivity required for the liner. In general, the coarser the soil, the more bentonite is required to achieve a given low permeability. The exact bentonite percentage for mixing would be determined using the results of both laboratory and field tests. The cost of bentonite and the cost of soil mixing are considered relatively high compared to the other two alternatives. The cost is even higher if the soil is not available from a borrow source near the project site. Should costs, material volumes, and construction scheduling prohibit the use of either of the above two alternatives, Alternative C would be recommended.

Details of the Preferred Alternative

From the standpoints of cost effectiveness, ease of obtaining governmental approval, and the substantive requirements of the RCRA, a 3-ft-thick compacted clay liner placed underneath an FML as the bottom component of a composite liner is recommended.

Soils that are appropriate for use in clay liner construction should have at least 50% fines (smaller than No. 200 sieve size), no more than 10% gravel size (larger than No. 4 sieve size), and no soil particles or clods larger than 2 in. in diameter. Furthermore, studies by Aughenbaugh (1990) (Ref. 66) and Mitchell and Jaher (1990) (Ref. 67) indicate that it is feasible to compact clayey soils with a liquid limit (LL) of about 30 to 50 and a plasticity index (PI) of

20 to 40 to provide suitable hydraulic conductivity (i.e., less than 1×10^{-7} cm/s). Therefore, such soils are considered suitable for the compacted clay liner materials. Such material is available in sufficient quantity at a potential borrow source.

The above recommendations for compacted clay liner are applicable to both the CSS and the VIT waste treatment alternatives.

Technical Uncertainties

MVE Table 5.2.5-9 shows the application and use of the observational method to estimate the probability of occurrences of various potential deviations or failure of a component or components in the primary composite liner consisting of an FML and a layer of CCL, and the effects on the entire foundation liner system design. Similarly, this table can also apply to the secondary composite liner consisting of an FML and a GCL. In conclusion, the probability of having both liner components fail and both liner systems fail totally during the required period is expected to be very low.

Design Criteria

Design Criteria:

- The compacted clay liner and geosynthetic clay liner hydraulic conductivity should be not greater than 1×10^{-7} cm/s.

Codes and Standards are listed in Section 5.2.5.3.9.

5.2.5.3 Leachate Collection and Removal System.

5.2.5.3.1 Functional Requirements. The functional requirements of the LCRS are to collect and remove all water, runoff, and leachate from within the disposal cell at the earliest practical time. Sources of leachate include the waste, construction water, and precipitation runoff from the waste. Leachate will continue to be collected and removed until leachate is no longer generated or until cessation of monitoring is allowed by regulators. The LCRS will help maintain separation of the leachate from the existing site groundwater contamination and will help prevent future contamination of the site groundwater by the leachate. The system will

allow monitoring of the disposal facility performance without having to rely on wells in the existing contaminated aquifer. Other functional requirements include preventing ponding on the liners, detecting leaks through the primary liner with the redundant LCRS, and preventing clogging of the system by migration of fines. The LCRS will collect and hold leachate for the duration dictated by treatment frequency and water treatment plant capacity.

5.2.5.3.2 Performance Requirements. The performance requirements of the LCRS are to minimize maintenance, avoid clogging throughout the design life, provide redundancy, ensure chemical compatibility with the leachate, and withstand all mechanical stresses due to settlement and overburden stress. The redundant LCRS should have a longevity equal to or exceeding that of the primary LCRS. The LCRS should not cause excessive settlement within the overlying waste or cover cracking. It should comply with all identified and potential ARARs.

5.2.5.3.3 Identification of Alternatives. Alternatives for the LCRS drain materials, filter materials, conveyance systems, and holding facilities are listed in MVE Tables 5.2.5-10 through 5.2.5-14.

5.2.5.3.4 Evaluation of Alternatives. MVE Tables 5.2.5-10 through 5.2.5-14 list the advantages and disadvantages of each of the different alternatives considered. The tables also list the criteria used in the evaluation process.

5.2.5.3.5 Selection of the Preferred Alternatives. The preferred alternatives selected for the LCRS are shown in Figures 5.2.5-3 through 5.2.5-5 for the CSS treatment option. Figures 5.2.5-3, 5.2.5-5 and 5.2.5-6 illustrate the VIT treatment option. The drain layer is comprised of a granular material on the cell bottom and a geonet on the excavation side wall or interior slope of the perimeter CFD. A granular filter layer separates the granular drain on the cell bottom from the overlying waste or geosynthetic clay liner. On the interior slope of the perimeter CFD, geotextile filters separate the waste and geosynthetic clay liner from the geonet drain layers. Within the granular drain layers on the cell bottom, slotted HDPE pipes surrounded by coarse gravel drains serve as the conveyance system. The pipes are designed to handle short-term flows, even though none are anticipated. The gravel drains will remain functional throughout the design life of the facility. The pipes and drains lead to holding facilities located outside of the disposal facility. HDPE sumps comprise the holding facilities, since the leachate volumes will be small; for large leachate volumes, lined and covered retention

basins are recommended. In either case, gravity drainage from the disposal facility is maintained throughout the design life of the facility.

5.2.5.3.6 **Details of the Preferred Alternatives.** The granular drain material placed on the bottom of the disposal cell directly above each of the liners is a sand and gravel material with a longevity that meets or exceeds the design life of the disposal facility. The granular drain material has a design hydraulic conductivity of 1 cm/s. The design gradation will be based upon a minimum hydraulic conductivity of 10 cm/s, thereby incorporating a safety factor of 10. The drainage layer is capable of keeping head buildup on the liner well below 1 ft, even during the construction and operations period when it directly catches all precipitation. A nominal layer 18 in. thick is recommended for the primary LCRS drain layer and 12 in. is recommended for the redundant LCRS drain layer. The slope of the layer is 2% perpendicular to, and a minimum of 1% parallel to, the collection pipes.

On the interior slope of the perimeter CFD or excavation side walls, the drain material is a geonet with a minimum transmissivity of 5×10^{-4} m^2/s. A safety factor does not need to be applied to the transmissivity because, in the unlikely event that the flow capacity of the drainage net is exceeded, the leachate or precipitation will simply flow to the cell bottom through the waste or along the waste and LCRS interface. The geonet is about 0.25 in. thick. The primary LCRS geonet will be extended up over the waste along the primary FML and waste interface to the point where the primary FML meets the cover FML.

Granular filters of graded sand and gravel separate the granular drain materials from the waste in the primary LCRS, and from the geosynthetic clay liner in the redundant LCRS. The granular filter has a hydraulic conductivity on the order of 1×10^{-2} cm/s and prevents migration of fines into the voids of the drain material. Because it is a natural material, it also has a longevity equal to or exceeding the design life of the disposal facility. A layer at least 6 in. thick is recommended.

A geotextile filter is used to separate the waste and geosynthetic clay liner from the geonet drain layers on the side slopes. An average opening size (AOS) no larger than U.S. Standard Sieve Size No. 70 is recommended to prevent excessive intrusion of fine particles. A heat-bonded, non-woven geotextile will prevent excessive intrusion of geotextile into the channels and voids of the geonet. During final design, it may also be determined that additional geotextile is required as a cushion between the various drain materials and FMLs to prevent

puncture. The primary LCRS geotextile filter will be extended up over the waste along the primary geonet and waste interface.

The collection pipes are slotted HDPE with a nominal diameter of 6 in. in the LCRS and 4 in. in the redundant LCRS. A standard dimension ratio (SDR) not exceeding 17.0 is recommended. Slots are required on the bottom half of the pipe. Minimum pipe slope is 1%. Pipes should have at least 3 in. of bedding below and 6 in. above. The pipe bedding may be the coarse gravel drain, the granular drain layer materials, and the granular filter. A pipe spacing of 400 ft is recommended based upon 1% risk-of-failure precipitation conditions. If an increased risk of exceeding capacity is acceptable, the pipe spacing may be increased.

The coarse gravel drains surrounding the pipes provide design redundancy and long-term means of removing leachate from the disposal facility. Hence, these drains must be sized to carry the long-term design infiltration rate. The sizing and gradation of the gravel drains will be determined during final design. Preliminary indications are that the infiltration rate is low enough for the granular drain layer itself to provide adequate hydraulic capacity. Again, being comprised of natural materials, the longevity of the gravel drain is at least as long as the disposal facility design life.

The pipes and coarse gravel drains exit the disposal cell by passing through the composite liner and beneath the perimeter CFD. Each pipe should exit the disposal facility separately, thereby creating multiple exit points which then feed into holding facilities located outside of the cell. The use of multiple exit points rather than a single point prevents catastrophic system failure should a single exit point clog or otherwise fail. The exit points will lead directly into one or more HDPE sumps located outside of the disposal facility. The HDPE sumps will allow gravity overflow into pipes leading to lined retention basins. If leachate flow rates are determined to be high, the exit points will connect into a collection manifold located outside of the disposal facility. The collection manifold will allow gravity flow into a lined, covered retention basin.

The redundant LCRS will also have multiple exit points that will lead into individual HDPE sumps. Individual sumps will provide a rough indication of the location of leaks through the primary composite liner. Flow rates are expected to be low and the volumes very small in the redundant LCRS, except in the case of extreme and catastrophic failure of the primary composite liner.

All LCRS components along the leachate design flowpath, up to the point of monitoring, must be double-lined to prevent potential uncontrolled exit through a single-lined component. The leachate is considered within the double-liner system until it has been monitored and/or treated. Otherwise, the double-liner system integrity will not be maintained and escape of leachate could go undetected.

Each sump or retention basin should be equipped with automated pumping, sensing, and alarm equipment to prevent overflow and escape of leachate from the system. Each sump or retention basin will require a power supply and pump station. Float switches, submersible centrifugal type pumps, and flow metering devices are required. Pump size is dependent upon the leachate flow rate, which has not yet been accurately determined. However, once the disposal facility is covered and closed, it is anticipated that flow rates will be quite low to nonexistent compared to the flow rates that occur prior to placement of waste over the LCRS. The pump stations will feed into force mains which lead to the treatment facility.

A treatment facility is required to monitor and/or treat leachate prior to discharge into the environment. The SWTP could provide this function during the cell construction period. After cell closure, the SWTP could continue to treat leachate, but it is sized for a capacity much greater than will be required to treat the leachate. Further evaluation may be required after long-term disposal facility performance data become available. Location and capacity are dependent upon numerous factors and will need to be addressed in final design. Based upon current available data, a small-capacity, trailer-mounted treatment plant may be sufficient.

5.2.5.3.7 Technical Uncertainties. The technical uncertainties are evaluated using the observational method and are listed in MVE Tables 5.2.5-15 through 5.2.5-19. The technical uncertainties of greatest importance are the leachate infiltration rate into the LCRS, the chemical characteristics of the leachate, and the longevity of the synthetic components. The infiltration rate during operations, after closure, and at steady-state conditions will affect the design of the coarse gravel drains, holding components, pumping system, and the treatment facility. Section 8, Disposal Facility Performance Assessment, provides data for final detailed design. Accurate characterization of the leachate will affect chemical and biological clogging potential, as well as potential chemical degradation of the synthetic components of the LCRS. Synthetics have a limited longevity that can only be predicted based upon accelerated testing and extrapolated data. Ongoing studies will provide data that will be used to address these issues.

5.2.5.3.8 Performance of Components. The recommended LCRS will meet the functional and performance requirements. The synthetic components of the LCRS provide the hydraulic capacity required to collect and quickly remove leachate from the disposal facility during the construction, operation, and closure periods. The predicted longevity of the synthetic components is on the order of hundreds of years. The period for which the sythentic components are required to function is possibly as short as 10 years to 50 years, based upon the current construction and system equilibrium scenarios. After this period, the synthetics remain functional and provide an additional safety factor against system malfunction. However, it is reasonable and conservative to assume that, at some point during the design life of the disposal facility, all synthetics will degrade and cease to function.

Use of synthetics in the LCRS and redundant LCRS on the interior slopes of the perimeter CFD does not pose ponding problems within the waste once the synthetics degrade. Percolating leachate that intercepts the interior slope liners will simply continue to flow downward through the waste or along the waste and liner interface until it reaches the bottom of the disposal facility.

The preferred LCRS conceputal design allows gravity drainage of leachate from the disposal facility throughout the design life of the facility. All drain layers placed on the bottom of the disposal facility are composed of natural materials with proven longevity. The redundant coarse gravel drains will provide flowpaths for the collected leachate. These drains can be tied into rock drains at some future date when leachate treatment and monitoring is no longer required. The rock drains can either lead to natural surface drainage features or allow seepage into or onto the surrounding site. However, the flow path or seepage path will be influenced by information gained during the leachate characterization and geochemical attenuation efforts. The flow path may require inclusion of an attenuation (geochemical) barrier.

During cell construction, the LCRS may also collect water used for dust control. A dust suppressant may be mixed with the water, but no adverse effects are anticipated. However, the potential for adverse effects should be considered during final design. Liner compatibility test results may also provide data that can be used in the assessment.

5.2.5.3.9 Design Criteria. The design criteria for the leachate collection and removal system were developed in a design basis memorandum (Ref. 64) and are listed below:

1. Use natural materials, where possible, to maximize longevity.

2. Implement stringent construction quality assurance and quality control procedures.

3. Granular drainage layer hydraulic conductivity ≥ 1 cm/s.

4. Geosynthetic drainage layer (geonet) transmissivity $\geq 5 \times 10^{-4}$ m^2/s.

5. Final slope of all LCRS components $\geq 1\%$.

6. Maximum allowable head on primary liner = 1 ft.

7. Minimize the time required to detect a leak past the primary liner.

8. Address waste form impact on the LCRS.

9. Minimize the number of collection pipes.

10. Minimize the number of cover and bottom liner penetrations.

11. The LCRS design should conform with the foundation grading plan rather than dictate it.

12. Safety factors for strength and flow for geosynthetics will meet or exceed those from Loerner (1990) (Ref. 68), as recommended in Section 7.2.1.4 of *Supporting Study 13* (Ref. 63): The safety factor for granular materials will be 10 for hydraulic conductivity; holding capacities will incorporate a safety factor of 20%, unless specific analysis shows a different factor to be more appropriate.

13. Filter criteria should be followed to prevent particle migration or clogging of components. Filter criteria are detailed in *Supporting Study 13* (Ref. 63).

14. The appropriate design storm, determined in *Supporting Study 27* (Ref. 42), should be used for the design of the operations period. The appropriate

infiltration rate for long-term conditions currently being determined in *Supporting Study 45* (Ref. 129), and the resulting data should be used for design.

15. Conventional pipe sizing methods are acceptable. Pipes must be permanently fastened together.

16. Required leachate holding capacity may be dependent upon the frequency of treatment and the capacity of the treatment facility.

17. All LCRS components located outside of the disposal facility must be double-lined.

18. Sumps and other holding facilities must be equipped with automated pumps, sensors, and alarms.

19. Seismic effects will be considered in the design, including seismic-resistant connections of pipes to sumps.

20. Sumps or appurtenant features of the LCRSs should be located within the 300-ft buffer zone. Individual sumps are preferred to identify leakage within major zones of the disposal cell primary liner.

21. Granular drainage layer and filter layer hydraulic conductivities can be calculated using published empirical correlations, such as Hazen's equation using D_{10}.

The applicable codes and standards are:

- 40 CFR 264
- DOE Order 6430.1A
- Occupational Safety and Health Administration
- American Society for Testing and Materials
- American National Standards Institute
- National Sanitary Foundation
- WSSRAP Project Procedures (including NQA-1 requirements)

5.2.5.3.10 Specifications. The specifications required for the leachate collection and removal system are listed below:

- Earthwork
- Geonets
- Geotextiles
- Aggregate drain materials
- Slotted HDPE drain pipe
- HDPE sumps
- FMLs

5.2.6 Waste Placement

5.2.6.1 General. The conceptual design for placement of waste in the disposal cell is discussed in this section. The discussion considers factors such as cell configuration, foundation conditions, and the type of waste treatment. This section also recommends areas for further investigation during final design.

Waste to be placed in the cell will include treated raffinate sludges, soils, metal, masonry block, rock, concrete, asbestos, wood, various wastes stored in Building 434, and miscellaneous debris. Raffinate sludges and some soils will be treated to form either a CSS grout or soil-like product or a VIT product (see Sections 5.3.2 and 5.3.3). Some of the wastes stored in Building 434 will also require treatment prior to placement in the cell.

Preliminary recommendations for waste placement are presented in the waste placement supporting study report (Ref. 58), which examined placement methods for the waste forms and quantities reported in numerous reports. General placement recommendations were developed in an MVE session on internal cell configuration (Ref. 69). Recommendations regarding placement sequence were also developed in an MVE session (Ref. 71).

5.2.6.1.1 Functional Requirements. The proposed disposal cell must be able to contain the anticipated volumes and types of waste and prevent the escape of contaminants into the environment. The proposed waste placement configuration within the disposal cell should restrict total and differential settlements to acceptable values, enhance the slope stability of the disposal cell embankment, and allow for the optimization of other cell components by the

strategic placement of waste within the cell. During construction, the sequence of operations should minimize the likelihood of off-site escape of contaminated water or air from the placed waste. Construction methods should minimize worker exposure to hazardous waste.

5.2.6.1.2 Performance Requirements. The waste in the disposal cell should be designed to remain stable for at least 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years (40 CFR 192). The placed waste should remain stable against slope failure and excessive settlement during long-term cell construction periods under static and seismic conditions. Radon migration from the site during waste placement should be kept below regulatory limits. Release of dust from the cell should be minimized. The potential for contamination of clean site soils or groundwater should be minimized. Regulations are discussed in more detail in Section 4.2.

The rate of delivery of various waste forms to be placed in the disposal cell may fluctuate due to waste availability, equipment downtime, and weather. The waste placement operation should be able to accommodate fluctuations in rate of delivery and change in the total quantities of each type of waste without compromising the integrity of the cell. During construction, the surface of waste in the disposal cell should be graded and maintained to provide adequate control of rainfall runoff at all times and to minimize construction complications. This is further addressed in Sections 5.2.8 and 5.2.9.

Any potentially reactive wastes and RCRA wastes will be treated prior to placement within the cell. Wastes that will be placed in the cell are not expected to have any potential to react with other wastes.

5.2.6.2 Placement Strategy.

5.2.6.2.1 Alternative Evaluation. Placement strategies for each significant waste form were discussed in *Supporting Study 9A* (Ref. 58). MVE Table 5.2.6-1 lists the alternatives for waste placement schemes and the number and size of cell construction phases. The alternatives evaluated include placing debris randomly and interspersed with CSS or VIT material, placing debris in a zoned fashion, and placing concrete rubble without using CSS grout to fill voids in the rubble. Criteria for evaluating the alternatives are listed in the table.

In general, only alternatives that were deemed feasible are included in the table. Other alternatives were dropped from further consideration.

Key criteria include worker safety, cell integrity, protection of the environment, facilitation of cell construction, minimization of voids and total cell volume, and maximization of waste bulk density. The advantages and disadvantages of each placement strategy and criteria used to evaluate the alternatives are listed in MVE Table 5.2.6-1.

5.2.6.2.2 **Details of Preferred Alternatives.** CSS Alternative. The preferred conceptual design for the CSS alternative is to place the waste during two primary waste placement phases plus a final closure phase. This provides the most flexible placement operation by allowing large enough work areas to simultaneously place several waste forms. The longer time between placement lifts resulting from a slower rise (about 2.5 ft per month) of lifts in a large working surface will allow set-up of the in-place CSS grout and dissipation of any significant heat generated by hydration of the CSS product. With larger phase areas, it will be easier to avoid creating pockets or zones of one particular waste form, because each waste form will be spread across a broad area. The primary disadvantage of using large phase areas is that more contaminated runoff will be generated than for the microphase approach discussed in Table 5.2.6-1, Item 3.

A large Phase I area is desirable because (1) when the operation is being learned and refined by the subcontractor, a larger area will result in less congestion, and (2) when the CSS product is being placed, it is desirable to have a slow rate of rise of lifts. Nearly all the CSS product will be placed during Phase I.

Within the Phase I area, placement operations for metal debris and concrete rubble will occur simultaneously with the entombment of the CSS grout-like product (Ref. 58). Some contaminated soil will also be placed, primarily as roads and berms, within the Phase I area. If final design calculations indicate there is enough capacity in Phase I, a third placement operation for contaminated soil may be used during Phase I, as depicted in Figures 5.2.6-1 through 5.2.6-5. Approximately 500,000 cu yd of waste will be placed during Phase I including all or nearly all of the metal, concrete, and treated raffinate sludge. The wastes in Building 434 may also be treated and placed at this time.

During Phase II, the waste will consist primarily of untreated contaminated soil and gravel. Phase II will include smaller volumes of composted wood, friable asbestos, and other minor waste forms, although these materials may be included in Phase I, if capacity and operational considerations allow. These materials should be evenly distributed to prevent localized differential settlement. Local or State regulations may restrict asbestos placement to designated areas to prevent its release to the environment should the cell need to be opened in the future.

The type of waste placed during the closure phase will be similar to that placed in Phase II, and the same recommendations will apply. Differential settlement due to different waste forms for Phase I and Phase II will be insignificant because of the gently sloping waste interface between the two phases. The closure phase will be sized to contain the contingency volume, which will be defined to a greater level of accuracy by the time construction of the cell closure phase has begun.

The waste should be placed to achieve homogeneity on a macro scale. Homogeneity on a macro scale refers to spreading out the waste forms to avoid large pockets or heavy concentrations of any one waste form, so that any given waste form has a relatively uniform thickness across a single cell phase. This will result in the least amount of differential settlement, easy adaptation to whatever waste form is available at a given time, and flexibility for varying rates of waste delivery and placement. No significant disadvantages of this alternative were identified. This method is discussed in Section 6.2.5.1.

VIT Alternative. For the VIT alternative, areally large phases are also recommended, although there is no need for the waste surface to rise slowly, because the treated product does not have to set before being covered with a subsequent lift. Large phases will allow rapid and efficient construction of the LCRS and large working areas, which ease congestion and increase the homogeneity of the placed waste. However, if the VIT alternative is pursued, the possibility of implementing microphases to reduce contaminated runoff from the cell should be further evaluated during final design, especially after Phase I completion.

The conceptual traffic patterns for the VIT alternative will be analogous to those shown in Figures 5.2.6-1 through 5.2.6-4. The main differences would be that voids in the concrete rubble would be filled with vitrified product, soil, or gravel, and the entombment of the metal debris would be with clean grout rather than CSS grout. Figure 5.2.6-5 shows a schematic

cross-section of the waste placement sequence for the CSS waste alternative and Figure 5.2.6-6 shows a schematic cross section of the waste placement sequence for the VIT alternative.

The vitrification process is expected to require more time to treat the sludges than the CSS process, and each phase would last much longer than for the CSS alternative (Ref. 71). With the additional time required to complete Phase I, exploratory work under Raffinate Pit 4 should be underway by the time Phase II of the cell is constructed. Thus, the actual waste volume will be known to a greater level of accuracy before the second phase is built. The second phase will be sized to accommodate (1) the wastes that do not fit in Phase I, plus (2) the refined contingency volume based on exploratory work performed during Phase I. Thus, a third phase will not be needed.

For the VIT alternative, a grout or soil-like CSS product, which could have been used to fill hard-to-reach spaces or irregularly shaped voids, will not be produced. Voids caused by hard-to-fill space or irregular shapes of some metal rubble in the cell could cause differential settlement of the cell cover when the metal collapses due to corrosion. Therefore, it is recommended that clean grout be used to fill the primary voids within these metal wastes. The clean grout is used to fill voids in the metal debris that would not otherwise be filled with contaminated soil or vitrified product. The clean grout used will therefore have a minimal effect on the total cell volume. To minimize the clean grout quantity used, as many voids in the metal as possible should be filled with contaminated soil or vitrified product.

Clean grout could be imported from an off-site vendor, or it could be produced in a small batch plant that could be constructed on site. Alternatively, a small CSS plant could be constructed to process enough sludge to produce sufficient grout to entomb the metal wastes. This grout would not be clean as it would be the product of processing contaminated sludge. However, this would require construction of an additional processing building; design and purchase of additional equipment, which would likely require disposal in the cell; and additional design and quality control activities. These considerations will result in potentially larger waste volume, higher cost, extended schedule, and more complex coordination of waste excavation, transportation, and placement to accommodate the additional CSS waste form. Therefore, clean grout from an off-site vendor is preferred.

5.2.6.2.3 Technical Uncertainties. MVE Table 5.2.6-2 shows the application and use of the observational method for general waste placement alternatives. Potential deviations

from the expected conditions are listed, and their effects on the design are noted. The primary concerns are to ensure there will be sufficient grout or soil-like product to entomb the metal and concrete, to ensure that the set rate of the CSS grout will be fast enough to support subsequent lifts when needed, and to refine the estimates of the actual volume of waste to be placed in the cell. No significant uncertainties were identified for the VIT alternative.

MVE Table 5.2.6–3 lists the additional data needed to properly assess technical uncertainties. During final design, it will be critical to accurately determine CSS grout volumes and total waste volumes, as described in the table.

5.2.6.3 Radon Control

5.2.6.3.1 Alternative Evaluation. An evaluation was made whether or not to place the more radioactive wastes (i.e., the treated sludges from Raffinate Pits 1, 2, 3, and 4, and the quarry bulk wastes) toward the center of the cell and away from the containment system. The potential advantage of this alternative is that it may be possible to minimize the thickness of the radon barrier in the cell cover. Key criteria include worker safety, cell integrity, protection of the environment, and ease of cell construction. The alternatives and criteria used for the evaluation, as well as advantages and disadvantages of each alternative, are presented with brief descriptions in MVE Table 5.2.6–4.

5.2.6.3.2 Details of the Preferred Alternative. It is recommended that the waste be placed randomly with respect to levels of radioactivity, with the following qualification. Less radioactive material should be placed in the upper few feet of the waste pile, provided little effort is required to achieve this. This allows the required thickness of the radon barrier to be reduced by 12 in. to 18 in. (Ref. 72). However, if waste availability makes it difficult to place only less radioactive material in the upper few feet of the waste pile, radon release can be adequately mitigated by placement of a conventional, relatively thin (about 2 ft to 3.6 ft thick) radon barrier (Ref. 72). When future radon emanation studies have been completed, this preferred alternative should be re-evaluated based on more detailed evaluation of the range of required radon barrier thickness.

5.2.6.3.3 Technical Uncertainties. MVE Table 5.2.6–5 shows the application and use of the observational method to waste zonation for radon control. The primary deviation

identified is that it may be convenient to place slightly radioactive waste at the top of the cell during Phase I.

Data needed to properly assess technical uncertainties are listed in MVE Table 5.2.6-6. During final design, the schedule of waste availability and level of radioactivity should be evaluated in regard to placement to minimize radon migration.

5.2.6.4 Design Criteria. Placement and compaction criteria were considered in the waste placement supporting study (Ref. 58). Table 5.2.6-7 summarizes compaction criteria for the major waste forms to be placed in the disposal cell.

No density testing will be required for CSS grout. The soil-like CSS product or the vitrified frit will be placed and compacted using conventional earthwork methods and equipment. Therefore, conventional methods should be used to determine the laboratory maximum dry density and optimum moisture content of the soil-like CSS product, vitrified frit, soils, and soil-like materials in conformance with ASTM D1557, modified Proctor criteria. If gravelly material is very uniformly graded and contains no sand or cohesive material, the material should be track-walked or the voids filled with CSS grout, but no density testing will be necessary. Quality control criteria for placement of material in the cell should conform to conventional earthwork criteria for critical jobs.

Laboratory testing to evaluate hydrocompression should be performed. Samples should be selected with properties representative of contaminated soils to be placed in the cell. Samples should be compacted to cover a range of relative compaction and water contents, loaded in a consolidation cell, and left until they reach equilibrium. They should then be saturated and the consolidation (or swell) response to wetting evaluated. See Ref. 58 for further discussion of hydrocompression.

5.2.6.5 Specifications. The specification required for waste placement is listed below:

- Waste placement and compaction (methods and/or performance criteria).

5.2.7 Waste Containment System

5.2.7.1 General. The disposal cell waste containment system is composed of three major components: the top cover system, the CFD, and the basal liner system. The following sections present details of the conceptual design for the cover system and the CFD. The waste containment system design is essentially the same for both the CSS alternative and the VIT alternatives.

The preferred top cover design is a multicomponent cover system. This system features various components, described in detail in Section 5.2.7.3, including:

- A vegetated top cover to protect against erosion due to precipitation.
- A radon barrier to limit radon emissions.
- An infiltration barrier to minimize runoff infiltration.
- A leak detection layer to monitor the effectiveness of the cover in preventing infiltration.

The CFD is designed to provide stable lateral containment of the entombed waste. The term clean-fill indicates that the material used for dike construction will be uncontaminated soil. The dike will have an exterior slope of 5H:1V and an interior (dike-waste interface) slope of 3H:1V to the mid-thickness of the waste. The dike will have a large embankment cross section constructed with engineered fill. The outside slope of the CFD exhibits a conceptually designed riprapped surface for erosion protection against the PMP design storm event. However, the sloping surface may be vegetated if a lesser design storm is allowed. As a result, the CFD will be a very stable structure that prevents the release of wastes and protects against erosion, biointrusion, and inadvertent intrusion by humans or animals. In summary, the CFD will:

- Reduce infiltration of water to the wastes.
- Control the flux of radon from the wastes.
- Inhibit roots from growing into the waste.
- Limit erosion of the component materials.
- Shed incidental precipitation.

- Deter animals and humans from digging through to the wastes.

Subsequent sections describe these and other waste containment system functions, and discuss how the selected components result in compliance with the general and specific functional and performance requirements. Figure 5.2.7-1 shows the main waste containment systems and components selected for the disposal cell.

5.2.7.2 Cover. The cover must shield disposal cell contents from the elements, protect them from inadvertent human and animal intrusion, control plant growth, preclude waste dispersion, and reduce and inhibit infiltration and radon flux. The performance goal of the cover is a 1,000-year life with no failure caused by:

- Biointrusion.
- Seismic force resulting from the maximum credible earthquake (MCE).
- Erosion by runoff from the PMP event.
- Infiltration (no more than 1 x 10^{-10} cm/s - short term, 1 x 10^{-8} cm/s - long term).

A compromise based on trade-off studies of the above criteria may be acceptable if no single alternative satisfies all goals. In no case will a performance period of less than 200 years be acceptable (40 CFR 192).

5.2.7.2.1 Cover Types

Functional Requirements

The functional requirements of the disposal cell cover are to:

- Reduce infiltration to the encapsulated materials.
- Reduce radon flux from the encapsulated materials.
- Prevent wind and water erosion of the encapsulated materials.
- Prevent human and animal intrusion into the wastes.

- Control or prevent plant growth on or in the wastes.

- Provide an aesthetic structure that blends into or visually complements the environment.

- Establish a system that enhances the performance of the disposal cell, while minimizing the requirement for long-term surveillance, monitoring observation, and maintenance or repair.

Performance Requirements

The cover of the disposal cell must perform satisfactorily for at least 1,000 years, to the extent reasonably achievable, or at any rate, no less than 200 years. To perform satisfactorily for such a period, the cover must remain intact to minimize the infiltration of water into the cell and the release of radon or other contaminants into the environment.

To achieve these performance requirements, the cell top cover must be resistant to erosion, root penetration, inadvertent human and animal intrusion, desiccation, and the harmful effects of freezing and thawing. This objective is achieved by placing layers of different types of materials over the waste, each material designed to handle one or more of the above factors that may impair disposal cell integrity.

Identification of Alternatives

MVE Table 5.2.7-1 lists the five alternative cover designs that were evaluated in the MVE sessions. Figures 5.2.7-2 through 5.2.7-6 illustrate the five covers. These range from the simple cover with a minimum number of components to the multicomponent cover which consists of many layers. Criteria for evaluating the alternative covers are listed in the table. Essentially, the criteria are that the cover should be effective, easy to construct, dependable, and aesthetically pleasing.

Evaluation of Alternatives

MVE Table 5.2.7-1 lists the advantages and disadvantages of each of the cover alternatives. The alternative with the most significant advantages is the multicomponent cover.

This cover provides an upper bound of maximum functions, minimum infiltration, and a rational compromise between vegetation and erosion control. The three-component infiltration barrier and the leak detection system beneath the infiltration barrier provide maximum practical control and monitoring of infiltration through the cover. The disadvantages of this cover are that it is relatively expensive and somewhat more difficult to construct than the other simpler covers.

The simple cover, as its name implies, is the simplest of the five covers. It costs the least, is the least complex protection from biointrusion, and has the shortest design life. The simple cover alternative has been included to provide a basis for comparison with the other more complex covers.

The RCRA cover is relatively inexpensive and complies with the requirements established by the EPA for the cover of a disposal cell containing RCRA wastes.

The double-drain cover derives its name from the presence of two drains. The uppermost layer of durable rock is designed to provide maximum achievable erosion protection. The drawback is that the rock reduces evaporation from the cover, which potentially increases infiltration. Also, a layer of rocks favors the invasion of deep-rooted, woody species that would have to be removed frequently to avoid root damage to the underlying layers.

The erosion resister is composed of a variety of layers. Although this cover effectively limits infiltration and biointrusion, it is relatively expensive.

The evaluation of the covers is not affected by the waste treatment method chosen, because it comes in contact with the waste only at the base of the radon barrier.

Selection of the Preferred Alternative

The multicomponent cover is the preferred alternative because it provides many significant advantages compared to the other alternatives. These include compliance with ARARs, erosion control, biointrusion control, maximum infiltration control, practical monitoring of seepage through the infiltration barrier, radon flux control, and an aesthetic vegetated top surface.

Details of the Preferred Alternative

The following is a brief description of each component in the multicomponent cover. A cross section of the cover is shown in Figure 5.2.7-7.

The bottom layer, which lies directly above the encapsulated materials, is the radon and infiltration barrier. Section 5.2.7.2.2 evaluates the required thickness of the radon barrier. A minimum thickness of 1.5 ft has been adopted because the barrier will not be reliable with smaller thicknesses. Placed in three, 6-in. lifts, it provides reasonable assurance against overlapping deficient zones.

An optional geogrid overlies the radon barrier. This is a very porous geosynthetic that functions as a leak detection system. Any infiltration through the infiltration barrier will enter the geogrid and flow downslope to emerge at the junction between the top slope and the side slope (or perimeter encapsulation system). Very low infiltration (1×10^{-7} cm/s or less) may not result in measurable flow in the leak detection system, but defects (holes or cracks) in the infiltration barrier will result in measurable flow.

The next component is the soil infiltration barrier. The infiltration barrier consists of three components: a soil layer, a bentonite layer, and a geomembrane. The lowest or bottom component is the soil layer. The soil is a low permeability (1×10^{-7} cm/s) material consisting primarily of silts and clays. The bentonite layer may be one of many commercially available geosynthetics that incorporate a thin layer of bentonite. Similarly, the geomembrane will be a commercially available material.

A bentonite layer, combined with a geomembrane, also called a geomat, will overlay the soil infiltration barrier. The bentonite layer comprises a relatively thin (10 mm to 25 mm) layer of natural material with a low hydraulic conductivity (1×10^{-9} cm/s). The bentonite augments the infiltration control provided by the radon barrier clays and silts. Also, the bentonite effectively seals any construction holes in the overlying geomembrane, and will take over as the lowest permeability element in the cover as the geomembrane degrades. The geomembrane slows the diffusion of moisture through the material. The combination of soil, bentonite, and geomembrane produces an infiltration barrier that has a hydraulic conductivity less than the basal liner system ($< 1 \times 10^{-7}$ cm/s and in accordance with the infiltration performance goals of at least 1×10^{-10} cm/s in the short-term and 1×10^{-8} cm/s in the long-term).

The geomembrane is covered by a bedding layer of sand. This layer serves first to cover and protect the geomembrane from puncturing or tearing by sharp particles in the overlying soil. Second, the sand, which must have a hydraulic conductivity greater than 1×10^{-1} cm, acts as a drain, shedding water that percolates through the overlying material. Finally, the sand may act as a capillary break to prevent water from percolating down from the overlying soil into the drain. The capillary break will generally deter root advancement because roots do not grow from relatively moist media into relatively dry media.

The drain layer is overlaid by the biointrusion barrier, a layer of large gravel and cobbles sized to impede burrowing animals. The thickness is selected to deter root penetration and may prevent inadvertent human intrusion. Being covered, it is unlikely this layer will be removed for alternative use.

Over the biointrusion barrier is a filter to prevent migration of the fine particles of soil from the overlying soil into the voids of the biointrusion barrier. An alternative to this filter is to "choke" the uppermost surface of the biointrusion barrier. This is accomplished by running a heavy vibratory compactor over the rock to crack the uppermost particles and produce fines to fill, block, or choke the layer voids, by placing soil of suitable gradation into the upper part of the biointrusion barrier, or by placing selected soil on the layer and working it in.

The filter, or choked zone, is overlaid with a root or growth zone, where the materials are selected to favor plant growth. In addition, this layer protects the infiltration and radon barrier from the deleterious effects of freezing and thawing.

The uppermost layer may be a gravel mulch, or soil covered with a thin veneer of rock, with gradation selected to enhance vegetation and simultaneously provide adequate erosion protection. Alternative components such as a rock-soil matrix or soil with abundant vegetation may be used to meet site-specific requirements and constraints.

Technical Uncertainties

MVE Table 5.2.7-2 shows the application of the observational method to the cell cover. The data quality objectives are listed for each area of technical uncertainty in MVE Table 5.2.7-3. In brief, the potential deviations affect the amount and type of vegetation which

will invade the cell cover. These should be determined through observing natural analogues as well as test covers.

Performance of Component

The multicomponent cover makes reasonable and practicable provision for radon flux control, infiltration reduction, biointrusion prevention, and stability. Similar covers built at other sites are performing in accordance with project surveillance and maintenance plans.

5.2.7.2.2 Cover as Radon Barrier

Functional Requirements

The radon barrier's function is to reduce the flux of radon from the encapsulated wastes to less than 20 pCi/m^2s. This is usually achieved by placing a barrier of soil or other natural material over the waste. The barrier slows the diffusion of radon through the material. The reduced diffusion velocity and the relatively short half-life of radon, compared to the travel time through the barrier, reduces the radon surface flux at or below the mandated limit. Functional requirements and the selection of the preferred radon barrier material are not affected by the treated waste form.

Performance Requirements

The radon barrier must perform satisfactorily for at least 1,000 years to the extent reasonably achievable. To perform satisfactorily for such a period, the radon barrier must remain intact (uncracked and with no root or animal holes). Cracks or other holes through the radon barrier allow the gas to pass rapidly from the waste to the environment. Furthermore, the radon barrier should remain relatively moist. The soil radon attenuation capacity is significantly affected by moisture because water occupies the soil pore spaces.

To achieve these performance requirements, the radon barrier must be protected from erosion, root penetration, human and animal intrusion, desiccation, and freezing and thawing. This is accomplished by placing additional layers of soil or rock over the radon barrier. To prevent cracking of the radon barrier caused by deformation of the wastes over which it is placed, the cell foundation and the wastes are engineered to prevent unacceptable total or

differential settlement (see Section 5.2.6). The radon barrier material should also be selected and engineered so that the cracking potential of the material itself is minimized.

Identification of Alternatives

Four alternative radon barrier designs were considered (MVE Table 5.2.7-4). These range from essentially no barrier (because wastes emanating the least radon are placed over wastes emanating greater amounts of radon), to the use of a thick layer of compacted clay. Criteria for evaluating the alternative radon barriers are listed in the table. Essentially, the criteria are that the barrier should be simple, durable, and reliable and should also provide a dual function as an infiltration barrier (see Section 5.2.7.2.5)

Evaluation of Alternatives

MVE Table 5.2.7-4 lists the advantages and disadvantages of each radon barrier alternative. The radon barrier with the most significant advantages is a layer of compacted clay and silt at least 18 in. thick. This type of barrier is easy to design and construct. It is durable, reliable, and accepted (DOE Order 6340.1A, *General Design Criteria*). Provided the appropriate materials are placed over the soil, the radon barrier may be easily protected from erosion, desiccation cracks, freezing and thawing effects, and root, animal, and human intrusion.

The only disadvantage is the need to select an appropriate soil and to control its placement density and moisture content. Cracking due to waste or foundation deformation may be controlled by selection of a suitable material, cell geometry (shape and thickness), waste and radon barrier placement techniques, and a sufficient overburden thickness.

Bentonite-amended sand may be used as a radon barrier where sufficient quantities of clay and silt are not economically available. It is difficult to mix and place, however, if done properly, low-permeability layers are produced. Both a clay and silt radon barrier and a sand amended with bentonite radon barrier may also be an acceptable infiltration barrier.

A bentonite mat would theoretically impede the radon flux. Alone, however, this is a relatively thin layer of naturally occurring material, and it is difficult to firmly establish that it will function as desired for the required performance period.

Waste placement should be sequenced to reduce the required radon barrier thickness if practical (see Section 5.2.6). Standard practice on the Uranium Mill Tailings Remedial Action (UMTRA) Project was to place a layer of soil at least 18 in. thick as a radon barrier, even if calculations demonstrate that the radon barrier thickness may be less than 18 in. because of the waste placement sequence. The radon barrier also doubles as an infiltration barrier. This was done as a matter of conservative radon control and because a layer of low permeability soil at least 18 in. thick is generally required for infiltration control.

Other materials such as asphalt have been considered for the radon barrier. Asphalt, however, has been rejected because it is difficult to ensure that it will not creep, crack, or slide off the waste over a 1,000 year period.

Selection of the Preferred Alternative

A layer of compacted clay and silt is the preferred alternative for the radon barrier, because such a radon barrier has a significant history of regulatory and industry acceptance, is easy to design and construct, is expected to remain intact (in an appropriately designed cover) for the required performance period, and attenuates radon flux (as measured on numerous UMTRA disposal cells where uranium mill tailings are encapsulated).

Details of the Preferred Alternative

The material should be relatively plastic (PI preferably over 20), and should have a low compacted permeability (i.e., a hydraulic conductivity less than 1×10^{-7} cm/s). The minimum thickness is dictated by constructibility and will be 18 in. placed in three lifts, each no thicker than 6 in. However, the actual thickness of the radon barrier will be established from actual waste configuration, and measurement of the radon emanation and diffusion properties of the wastes placed in the 10 ft below the radon barrier and corresponding characteristics of the radon barrier material. *Supporting Study 19C* (in progress) (Ref. 72) estimates that the minimum radon barrier thickness for a CSS waste will be 18 in., and the maximum thickness will be 152 in. These calculations are based on reasonable, although conservative, assumptions about the range of waste and radon barrier material parameters that will be measured and confirmed during design. In a similar manner, the minimum radon barrier thickness for VTT waste is 18 in., and the maximum thickness is 137 in. The radon barrier soil will be compacted into place, to a density in excess of the 95% maximum dry density as determined by standard Proctor

(ASTM 698) and generally wet of optimum moisture content of standard Proctor compaction. The thickness of material placed over the radon barrier will exceed the freeze and thaw depth at the site (approximately 42 in.).

Technical Uncertainties

MVE Table 5.2.7-5 documents the application and use of the observational method to the radon barrier. The data quality objectives are listed in MVE Table 5.2.7-6. In brief, potential deviations affect actual emanation characteristics of the waste, waste placement sequence, and radon attenuation characteristics of the radon barrier soil. These may be measured during construction and immediately prior to placement of the radon barrier. During final design, the anticipated or most likely values and feasible deviations will be established by testing candidate materials.

Performance of Component

The radon barrier of compacted clay and silt, protected from desiccation cracking, erosion, and freeze and thaw by the overlying cover components, and protected from cracking by appropriate foundation preparation and waste placement, will function properly for the required period. The materials will not degrade. The moisture content is likely to remain above the minimum for design performance (that associated with a -15 bar capillary suction), hence, the radon flux will always be considerably less than the specified maximum of 20 $pCi/m^2/s$.

5.2.7.2.3 Cover for Erosion Control

Functional Requirements

The erosion barrier will reduce the potential for erosion of soil from the cell cover, prevent the development of gullies, and protect the underlying cover components from erosion. Waste form (VIT or CSS) does not affect erosion control considerations.

Performance Requirements

The erosion barrier must perform satisfactorily for at least 1,000 years, to the extent reasonably achievable. To this end, the erosion barrier materials should not be eroded by runoff

from the design PMP. Furthermore, the material in the erosion barrier must remain intact. If rock is used, it must be durable; if vegetation is used, it should be self-sustaining.

Identification of Alternatives

MVE Table 5.2.7-7 lists five alternative top slope erosion barrier designs. These range from vegetated soil to rock. Criteria for evaluating the alternative top slope erosion barriers are listed in the table. The criteria are that the barrier should be effective, reliable, and easily maintained.

Evaluation of Alternatives

MVE Table 5.2.7-7 lists the advantages and disadvantages of the alternative top slope erosion barriers. The barrier with the most significant advantages is the clump grass in vegetated gravelly soil. Provided the percentage of gravel in the mixture is appropriate, the material provides erosion resistance and supports the vegetation. The disadvantage of this combination is that it requires periodic maintenance.

The vegetated soil is aesthetically pleasing and relatively inexpensive, but provides limited erosion resistance and requires significant upkeep.

The gravel mulch is also relatively inexpensive and limits infiltration. However, this material does not provide good erosion protection.

Both the rock with soil-filled voids and the rock top components provide good erosion protection. The rock with soil-filled voids has high constructions costs. The disadvantages of the rock layer are its poor aesthetics and inadequate function as an infiltration barrier. Significant quantities of rock in the upper cover component may encourage or promote deep rooting species. This may result in considerable maintenance to remove vegetation or cover damage by the deep roots.

Selection of the Preferred Alternative

A layer of clump grass vegetated gravelly soil is selected as the preferred alternative erosion barrier. The clump grass provides good erosion protection and also has high public acceptance.

Details of the Preferred Alternative

The gradation of the gravelly soil will be based on the requirements of sufficient fines to support the selected vegetation and sufficient gravel to resist erosion. The gravelly soil must contain organic material in sufficient quantity to support vegetation, and the gravels should be durable.

Technical Uncertainties

Table 5.2.7-8 shows the application of the observational method to selection of the top erosion barrier. Actual gravel and soil gradations and ratios will be based on erosion protection requirements and vegetation support needs. *Supporting Study No. 14, Land Disposal Facility Alternative Cover Assessment* (Ref. 73) gives specific rock sizes (D_{50}) for various slope lengths and design storms. The species of vegetation used shall be determined through natural analogues, consultation with the Soil Conservation Service, and the results of test cover plots. MVE Table 5.2.7-9 lists the data quality objectives for each area of uncertainty. In brief, potential deviations affect the type of vegetation established as well as erosion characteristics.

Performance of Component

The erosion barrier of clump grass vegetated gravelly soil should protect the underlying layers from erosion and will function effectively for the required period. In particular, the clump grass will be self-sustaining, and the combination of roots and gravel in the upper layer of soil will resist erosion by both normal and intense precipitation runoff. See Figure 5.2.7-8.

5.2.7.2.4 Cover for Biointrusion Control

Functional Requirements

The biointrusion barrier will reduce two modes of biointrusion: (1) plant intrusion, and (2) animal and human intrusion. This will be achieved by placing a layer of cobble and gravel, thick soils, or herbicide imbedded geogrids over the waste. Biointrusion considerations are not affected by the waste form (VIT or CSS).

Performance Requirements

The biointrusion barrier must perform satisfactorily for at least 1,000 years, to the extent reasonably achievable. To perform satisfactorily for such a period, the material must be durable and remain intact. If the biointrusion barrier is a layer of cobbles, the material gradation must prevent the passage of finer grained soils into the rock voids; this will preclude development of soils that support root penetration.

Identification of Alternatives

MVE Table 5.2.7-10 lists three alternative biointrusion barrier designs. These vary in type from naturally occurring materials to man-made geosynthetics. Criteria for evaluating the alternative biointrusion barriers are listed in the table. Essentially, the criteria are that the barrier should be simple, durable, reliable, and possibly also function as a drain.

Evaluation of Alternatives

MVE Table 5.2.7-10 lists the advantages and disadvantages of the alternative biointrusion barriers. The biointrusion barrier with the most significant advantages is a layer of cobble and gravel. It serves a dual function as a drain. The disadvantage of this type of biointrusion layer is the possibility of the voids filling with silt. This can be avoided by placing or forming a filter of finer grained material above the biointrusion layer to filter and stop the migration of particles into this layer.

Thick soils may be used as a biointrusion barrier where sufficient quantities of appropriate soils are available. The thickness of the soils necessary to provide proper protection

from deep rooting species will be such that large quantities of soil will be needed to construct the cover, which in turn will increase the height and volume of the disposal cell.

A geogrid with time-released herbicides would theoretically preclude plant growth. Alone, however, it is difficult to establish that it will unequivocally function as desired for the required performance period. Its effectiveness in deterring burrowing animals is also in question.

Selection of the Preferred Alternative

A layer of cobble and gravel is selected as the preferred alternative biointrusion barrier, because such a biointrusion barrier has a significant history of regulatory and industry acceptance, is easy to design and construct, will remain intact (in an appropriately designed cover) for the required performance period, and has been proven to limit biointrusion.

Details of Preferred Alternative

The material for the biointrusion barrier will be a cobble and gravel mixture from the nearest available source. This layer will be three times the maximum diameter of the cobble (1 ft to 2 ft thick), providing a minimum of two void spaces the roots would have to penetrate. The individual stones will have a mean mass greater than one-third the mass of local burrowing animals. Studies *(Supporting Study 43, The Biological Systems Analysis Report* in progress) [Ref. 74]) have been performed on the effectiveness of buried, loose cobble layers, illustrating their ability to impede burrowing by mammals. The cobble layers discourage intrusion and cover material and waste transport by ants which, if uncontrolled over long periods, could excavate substantial quantities of materials.

Technical Uncertainties

MVE Table 5.2.7-11 shows the application and use of the observational method to the biointrusion barrier. Ecological studies have been undertaken to determine and characterize local flora and fauna. Figures 5.2.7-9 and 5.2.7-10 illustrate some possible failure scenarios. The results from these studies will assist in determining the actual thickness of the biointrusion layer as well as the size of the cobbles necessary to meet functional requirements.

MVE Table 5.2.7-12 lists the data quality objectives for each area of technical uncertainty. In brief, the potential deviations affect the sizing of the cobbles as well as the type of material that needs to be placed over the biointrusion barrier. These will be determined by *Supporting Study 43, The Biological Systems Analysis Report* (in progress) (Ref. 74).

Performance of Component

The biointrusion barrier of specifically sized cobble and gravel, will function effectively for the required period. The materials will not degrade. The thickness and quality of the soil in the upper layers (combined with the lack of rock in those layers) will determine how much physiological stress exists to encourage downward root advancement. The buried cobble biological barrier can be expected to deter root advancement, except during extreme stress (drought in the overlying layers).

5.2.7.2.5 Cover as Infiltration Control

Functional Requirements

The infiltration barrier will reduce the flux of water to the encapsulated wastes to no more than 1×10^{-7} cm. This is usually achieved by placing a geomembrane or a layer of low permeability clay over the waste. The barrier impedes or slows the passage or flow of moisture through the material. A soil infiltration barrier may also function as a radon barrier, and if this is done, the resulting layer is frequently referred to as a radon and infiltration barrier. The waste form (VIT or CSS) does not affect consideration of cover infiltration.

Performance Requirements

The infiltration barrier must perform satisfactorily for at least 1,000 years, to the extent reasonably achievable. To perform satisfactorily for such a period, the material of the infiltration barrier must remain intact (uncracked and with no root or animal holes). Cracks or other holes through the infiltration barrier allow moisture to pass rapidly from the environment to the waste.

To achieve these performance requirements, the infiltration barrier must be protected from erosion, root penetration, inadvertent human and animal intrusion, desiccation, and freezing

and thawing. This is done by placing additional layers of soil and rock over the infiltration barrier. To prevent cracking or tearing of the infiltration barrier by deformation of the wastes over which it is placed, the cell foundation and the wastes must be selected, or engineered, to preclude unacceptable total or differential settlement.

Identification of Alternatives

MVE Table 5.2.7-13 lists five alternative infiltration barrier designs. These range from a geomembrane through a compacted silt and clay layer to a combination of both. Criteria for evaluating the alternative infiltration barriers are listed in the table. Essentially, the criteria are that the barrier should be simple, durable, and reliable.

Evaluation of Alternatives

MVE Table 5.2.7-13 lists the advantages and disadvantages of the alternative infiltration barriers. The infiltration barrier with the most significant advantages is a combination of compacted clay and silt of at least three 6-in. layers (a total of 18 in. thick), bentonite mat, and a geomembrane. This is illustrated in Figure 5.2.7-11. Provided appropriate materials are placed over the soil and the FMLs, it may easily be protected from erosion, desiccation, freezing and thawing, and root, animal, and human intrusion.

The disadvantages are the need to select an appropriate soil and to control its placement density and moisture content. Cracking, due to waste or foundation deformation, may be controlled by selection of a suitable geometry (shape and thickness), waste placement techniques, and a sufficient overburden thickness. This configuration is also relatively expensive.

Bentonite-amended sand may be used as an infiltration barrier where sufficient quantities of clay and silt are not economically available. It is difficult to mix and place bentonite-amended sand; although, if done properly, it yields a low permeability layer. Both a clay and silt radon barrier, and a sand amended with bentonite radon barrier may provide a dual function as an infiltration barrier.

A bentonite mat would theoretically impede infiltration. If used alone, however, it is a relatively thin layer of naturally occurring material, and it is difficult to establish that it will function as desired for the required performance period.

A geomembrane has the advantage of being easy and inexpensive to place, but its performance over the long term is questionable due to its limited life.

Selection of the Preferred Alternative

A multicomponent infiltration barrier is selected as the preferred alternative, because such an infiltration barrier is made up of components that individually, as well as in combination, have a significant history of regulatory and industry acceptance. It is also easy to design and construct and will remain intact (in an appropriately designed cover) for the required performance period.

Details of the Preferred Alternative

The soil material for the infiltration barrier will be excavated from a selected borrow source (Section 5.7). This material will contain significant percentages of clay and silt, and only a minor percentage of sand.

The material should be relatively plastic (PI preferably over 20), and should have a low compacted permeability. The average saturated hydraulic conductivity of the infiltration barrier shall be no greater than the lesser of 1×10^{-7} cm/s or the average hydraulic conductivity of the natural materials in the liner system at the base of the disposal cell. The minimum thickness will be 18 in. placed in three lifts, each no thicker than 6 in. The soil will be placed and compacted to at least 95% of maximum dry density as determined by the modified Proctor test (ASTM D1557), and at a moisture content wet of optimum. Placement and compaction of the underlying wastes will be necessary to ensure such densities are obtainable.

The geomembrane shall be made of 60-mil-thick, textured HDPE. The bentonite mat shall be a layer of bentonite between two geotextiles or bonded to the geomembrane. (Numerous commercial bentonite geomats are readily available.) The thickness of the material placed over the multi-component infiltration barrier will exceed the freeze and thaw depth at the site (approximately 42 in. - see *Supporting Study 14 Land Disposal Facility Alternative Cover*) (Ref. 73). Beneath the three component infiltration barriers there will be a geogrid to monitor the performance of the infiltration barrier.

The radon barrier beneath the geogrid will function as a backup, secondary, or redundant infiltration barrier. Because the radon barrier soil is of low permeability (approximately 1×10^{-7} cm/s), it will control seepage in the event of significant infiltration through cracks or holes in the infiltration barrier.

Technical Uncertainties

MVE Table 5.2.7-14 shows the application and use of the observational method to the infiltration barrier. The data quality objectives are listed for each area of technical uncertainty in MVE Table 5.2.7-15. In brief, the potential deviations affect the actual infiltration of moisture through the cell cover. These are all easily measured during construction and immediately prior to placement of the radon barrier. During detailed, final design, the anticipated or most likely values and the feasible deviations will be established by testing candidate materials.

Performance of Component

The infiltration barrier of compacted clay and silt, a bentonite mat, and a geomembrane protected from desiccation cracks, erosion, and freeze and thaw by the overlying cover components, and protected from cracking and sundering by appropriate foundation preparation and waste placement, will function as desired for the required period. Although the FML may degrade over time, the soil materials will not degrade, thus providing redundancy, and ensuring minimal infiltration.

The performance of the infiltration barrier will be monitored by observing and measuring excess flow (if any) from the geogrid leak detection system placed beneath the infiltration barrier components.

5.2.7.2.6 Cover As a Drain

Functional Requirements

The drain and bedding layer has two functions. The first is to be the zone through which water seeping through the overlying soil is shed off the cover so that infiltration to the wastes is controlled. In this role, the drain must be sufficiently permeable to provide rapid water flow

and complete shedding. Also, the drain must function to prevent erosion of the underlying radon and infiltration barrier by water flowing in the drain.

The second function of the drain is to act as a bedding layer that prevents the overlying gravel and cobbles of the biointrusion layer from punching, pitting, or deforming the surface of the underlying geomembranes and radon and infiltration barrier soils.

The waste form (VIT or CSS) does not affect the drain selection or design.

Performance Requirements

The drain and bedding layer must perform satisfactorily for at least 1,000 years to the extent reasonably achievable, and at any rate for 200 years. In order to perform satisfactorily for such a period, the material of the drain layer must remain intact, i.e., must not degrade from a sand to a silt or clay with a lower hydraulic conductivity. The material must be protected from erosion. The gradation of the material must be coarse enough to provide a high enough permeability to rapidly shed water, and must be fine enough to preclude erosion by water flowing in the drains.

Selection of a suitable soil for the drain or bedding layer accordingly involves careful balancing of the potentially conflicting demands of coarse, permeable materials to increase flow or shedding rates, thus lowering total infiltration, and fine soils to most effectively eliminate erosion of the underlying radon and infiltration barrier soils.

Identification of Alternatives

MVE Table 5.2.7-16 lists three alternative drain layer designs. They range from allowing the biointrusion barrier to serve a dual function as a drain, to naturally occurring materials (sand), to a geosynthetic. Criteria for evaluating the alternative drain layers are listed in the table. Essentially, the criteria are that the layer should be easy to construct, effective, and last for as long as practical.

Evaluation of Alternatives

MVE Table 5.2.7-16 lists the advantages and disadvantages of the alternative drain layers. The material with the most significant advantages is a layer of coarse sand at least 6 in. to 12 in. thick. This approach is easy to design and construct and is also well-established, proven, and accepted. Another advantage is that it serves a dual function as a bedding layer.

The major disadvantage to this type of drain is that it necessitates a significant level of quality assurance to ensure proper placement and, ultimately, satisfactory performance.

The geonet is a plastic grid sandwiched between two layers of geotextile. The geotextile acts as a filter, trapping small particles, and the plastic grid channels the water off the cover. The geonet is easy to place, but its performance over the entire design life of the cell is questionable; it will probably deteriorate within the first 50 years to 200 years of the cell's life.

The biointrusion barrier would theoretically serve a dual function as a drain, but would not protect the geomembrane and fine-grained soils of the underlying layers from erosion or pitting. Such pitting could result in depressions in which water could pond and subsequently seep into the infiltration barrier. Also the increased flow in the large voids of the biointrusion barrier may erode the underlying soil of the radon and infiltration barrier.

Selection of the Preferred Alternative

A layer of coarse sand to gravelly sand is selected as the preferred alternative drain layer. This is because such a drain barrier has a significant history of regulatory and industry acceptance and will also serve as a bedding layer. It will also remain intact (in an appropriately designed cover) for the required performance period, and is demonstrated to expedite the flow of water off the cover.

Details of the Preferred Alternative

Selection of a suitable sand for the drain layer involves careful balancing of the potentially conflicting demands of coarse, permeable materials to increase flow or shedding rates, thus lowering total filtration, and fine soils to most effectively eliminate erosion of underlying soils. The material should be relatively permeable, and have a hydraulic conductivity

of 1 x 10^{-1} cm/s or greater. The design of the drainage or bedding layer is dependent upon cover slope, median grain size, overtopping discharge, sediment removal, interstitial velocity, and drainage rate. A bedding layer is required to protect the radon barrier from erosion. A median bedding layer grain size (D_{50}) of 8 mm is recommended to achieve this purpose; finer bedding materials are highly susceptible to entrainment into overtopping flows.

Technical Uncertainties

MVE Table 5.2.7-17 shows the application and use of the observational method to the drain layer. Actual flow rates through the drain can be determined using conventional technical procedures for assessing flow through porous media. In MVE Table 5.2.7-18, the data quality objectives are indicated for each area of technical uncertainty. In brief, the potential deviations affect the flow rate through the drain and the erosion potential of the infiltration barrier. Figure 5.2.7-12 shows a potential failure scenario. During final design, the anticipated or most likely values and the feasible deviations will be established by testing candidate materials.

Performance of Component

The drain and bedding layer of coarse sand, protected from erosion by overlying cover components, will function as desired and perform for the required period. This layer of sand should be sufficiently fine to control erosion, but sufficiently permeable to shed water rapidly and preclude the permanent saturation that is conducive to root establishment and sustenance.

5.2.7.2.7 Interim Cover for Dust Control

Functional Requirements

The interim cover for dust control must cover or control as-placed wastes so that they are not a source of dust during the placement of subsequent wastes. The interim cover must preclude, or at least minimize, the ability of wind to pick up dust particles from the surface of the waste. Dust control will not be a concern for the VIT waste form.

Performance Requirements

The interim cover must last as long as it takes to return to the zone of placed wastes and place a subsequent lift, or to place the final cover components.

Identification of Alternatives

Alternative dust control covers are a thin film of water; a synthetic, commercially available dust suppressant film; and CSS treated waste of a consistency that is not susceptible to dust erosion.

Evaluation of Alternatives

A water film, as the interim dust control cover, is placed, and maintained in place, by repeated watering with a spray truck. Depending on weather conditions, frequent watering may be necessary. The advantage of this approach is the low cost. The significant disadvantage is the potential that excess, surplus water is added to the wastes. The excess or surplus water drains, with time, from the wastes via the drains. This increases both the quantity and the time of transient drainage of contaminated water from the disposal cell.

The properties of commercial dust suppressants vary widely. An examination of the potential applicability of the various types is not undertaken here. The major disadvantages are their high cost and short effective performance period. Also, they constitute a source of new chemicals that are introduced into the cell; these chemicals may interact adversely with the many constituents in the cell, and will ultimately seep from the cell.

CSS treated material of a consistency that is not susceptible to dust erosion on an interim basis is an efficient use of material that must go into the cell. It is cost effective, easily done, and has no effect on the performance of the cell. The disadvantage is that a specific blend of waste and reagents may be required and attention will have to be paid to the placement location and sequencing of the CSS treated product to achieve interim dust control.

Selection of the Preferred Alternative

The use of CSS treated material that is not susceptible to dust is the preferred alternative. As necessary, this may be augmented by the use of a water film sprayed from a water truck.

Details of the Preferred Alternative

The details of the CSS material will be established once the treatability testing is completed.

Technical Uncertainties

It is feasible that a CSS product that will resist dust production by the wind may not be able to be produced and spread in concert with the placement of other wastes. If this occurs, water spraying will be the preferred procedure.

Performance of the Component

Both water and a CSS interim cover will control dust emanation from the surface of the wastes.

5.2.7.3 Perimeter Encapsulation

5.2.7.3.1 General

Functional Requirements

The perimeter encapsulation system's function is to encapsulate the wastes in the cell in such a manner that the cell is stabilized, erosion is controlled, and infiltration and radon emission standards are met. This may be achieved by constructing a dike of uncontaminated soil around the perimeter of the area where the waste is to be placed. Other perimeter encapsulation methods exist and are discussed and evaluated in this section. Selection of the perimeter encapsulation system is not affected by the waste form (VIT or CSS).

Performance Requirements

The system must remain stable for 1,000 years to the extent achievable. It must prevent dispersion of contaminated materials by wind, water, animals, and humans, as well as minimize inadvertent intrusion by humans, animals, and plants. Radon flux from the outer surface must average less than 20 $pCi/m^2/s$. The system must also minimize infiltration, the subsequent seepage of leachate from the disposal cell, and the need for long-term maintenance.

Identification of Alternatives

MVE Table 5.2.7-19 lists the three alternative perimeter encapsulation systems. These may be divided into two types: a multicomponent cover composed of layers of soil and rock or a CFD of compacted soil and rock. Figure 5.2.7-13 shows a comparison of the two. Criteria for selecting a multicomponent cover or a CFD are listed in the table. Essentially, the criteria are that the perimeter encapsulation system should be reliable, effective, and logistically feasible.

Evaluation of Alternatives

MVE Table 5.2.7-19 lists the advantages and disadvantages of the alternative perimeter encapsulation systems. The multicomponent cover is less expensive and requires less space, but it is also susceptible to biointrusion and requires more quality control during waste placement.

The system with the most significant advantages is the CFD. It has a high factor of safety for slope failure, resists biointrusion, and minimizes worker exposure during construction.

Various CFD geometries include the vertical-face CFD, as shown in Figure 5.2.7-14, and a triangular dike as shown in Figure 5.2.7-15. The vertical-face CFD has all the advantages of the CFD configuration shown in Figure 5.2.7-13 and also requires less clean-fill to construct. The drawbacks of this configuration are that it is complex to construct.

Selection of the Preferred Alternative

The CFD with a variable or reversed sloped inner face is selected as the preferred alternative. It performs better than, or is preferred to, the multicomponent cover with regard

to constructibility, waste accommodation, erosion protection, long-term stability, and biointrusion control.

Details of Preferred Alternative

Figure 5.2.7-16 details the CFD and associated cover and liner layers. The outside slope of the CFD is 5:1, giving it a considerably higher factor of safety against slope failure for a given geometry than a multicomponent cover. The sheer bulk of the CFD provides ample space and volume so that roots from vegetation growing on the dike might thrive without entering the wastes or compromising the integrity of the waste encapsulation system. Rock is used on the CFD because it provides greater erosion protection than vegetation on the side slope (Section 5.2.7.3.2). The soil used to construct the CFD will be uncontaminated fill compacted in place.

Technical Uncertainties

MVE Table 5.2.7-20 shows the application of the observational method to the CFD. The borrow source for the fill material is yet to be determined, as is the cell volume. As shown, potential deviations will affect the materials, design layout, and performance. During final design, the anticipated, or most likely, values and feasible deviations will be established by testing candidate materials. Table 5.2.7-21 lists the data quality objectives for each area of uncertainty.

Performance of Component

The CFD of compacted soil and rock with a rock cover, properly constructed, will function as desired and perform for the required period.

5.2.7.3.2 Erosion Protection - Side Slopes

Functional Requirement

The function of the erosion barrier on the side slopes of the disposal cell is to prevent erosion of the upper components of the perimeter encapsulation system (a CFD, or a

multicomponent cover). The erosion barrier must preclude soil or rock movement by runoff from both normal and intense precipitation.

Performance Requirements

The erosion barrier must perform satisfactorily for at least 1,000 years to the extent achievable, and at any rate for 200 years. To perform satisfactorily for such a period, the material of the erosion barrier must resist erosion by the design PMP. Gullying must be controlled or limited. Furthermore, the material for the CFD erosion barrier should be durable rock, or self-sustaining vegetation, that resists deterioration, which could lead to the scenario shown in Figure 5.2.7-17.

Identification of Alternatives

MVE Table 5.2.7-22 lists two alternative CFD erosion barrier designs. These are either rock or soil and gravel on which vegetation is encouraged. Criteria for evaluating the alternative CFD erosion barriers are listed in the table. Essentially, the criteria are that the barrier be durable, reliable, aesthetically appealing, and maintenance free.

Evaluation of Alternatives

MVE Table 5.2.7-22 lists the advantages and disadvantages of the alternative CFD erosion barriers. The barrier with the most significant advantages is the rock cover. If the rock is sized properly, it will provide excellent erosion protection with minimal maintenance. Although it is somewhat more constructible than the vegetated cover, it lacks the aesthetic appeal that vegetated slopes may have.

The vegetated cover is visually appealing, but it may initially require more maintenance. It provides moderate erosion protection, which is a major concern for the side slopes. If public concerns or other institutional preferences dictate, vegetation may be used. Monitoring the vegetated cover's performance may be undertaken for the first 50 years of the cell's life, and if determined to be ineffective or unsatisfactory, a rock layer could be placed over the CFD outer face.

Selection of the Preferred Alternatives

A layer of rock is selected as the preferred alternative CFD erosion barrier. It consistently scores higher in the areas of performance, constructibility, and erosion protection.

Details of Preferred Alternative

The gradation of the rock on the CFD will be based upon the slope of the CFD and the PMP figures. The rock must also be durable and remain intact during the entire 1,000 years design life of the cell. Procedures to evaluate rock quality were developed for the UMTRA Project to help assess the durability of rocks for the long (1,000-years) design life of the structure. A score of 80 or above indicates good sound rock. Rocks scoring between 50 and 65 should not be used in frequently saturated areas. Rocks scoring below 50 should not be used under any circumstance (*Supporting Study 6A, Borrow Material and Borrow Area Selection Criteria*) (Ref. 20).

Technical Uncertainties

MVE Table 5.2.7-23 shows the application of the observational method. Actual rock gradations will be established based on erosion protection requirements. Rock durability will be determined through additional studies of available borrow material. MVE Table 5.2.7-24 lists the data quality objectives for each area of uncertainty. In brief, the potential deviations affect the CFD's resistance to erosion by deterioration or gullying.

Performance of Component

The rock cover erosion barrier on the CFD will protect the underlying layers from erosion and will function effectively for the required period.

5.2.7.3.3 Biointrusion Barrier

Functional Requirements

The biointrusion barrier's function is to reduce or eliminate biointrusion into the encapsulated waste. There are two types of biointrusion: (1) plant intrusion, and (2) animal and human intrusion.

Performance Requirements

The biointrusion barrier must perform satisfactorily for at least 1,000 years to the extent reasonably achievable. To perform satisfactorily for such a period, the material must remain intact, protected from the detrimental effects of erosion.

Identification of Alternatives

MVE Table 5.2.7-25 lists alternative biointrusion barrier designs. The approach to biointrusion for the CFD is radically different from that used in the multicomponent cover. The philosophy for the multicomponent cover was to place a layer of material that would inhibit or deter root advancement into the underlying radon barrier. The philosophy for biointrusion for the CFD is to provide a large quantity of soil, allowing enough room for roots to grow yet not penetrate the waste. Human and animal intrusion is prevented by the riprap and by the mass of the CFD.

Evaluation of Alternatives

MVE Table 5.2.7-25 lists the advantages and disadvantages of the alternative biointrusion barriers. The rock-covered CFD and the soil and vegetation-covered CFD are identical except for the top layer of material, in that they both rely on the bulk of soil that constitutes the mass of the CFD. The vegetated cover has a good public perception, but does require periodic maintenance. The nature of the vegetation established on the CFD will determine its effectiveness in allowing certain deep-rooting species to grow, i.e., sod-type grass inhibits the establishment of woody species.

The rock cover incorporates both approaches to biointrusion. The rock layer itself limits the establishment of most vegetation. The plants that do get established on the CFD will have a large mass of soil to root in without causing damage.

Selection of the Preferred Alternative

The rock covered CFD is the preferred alternative biointrusion barrier because it will provide good erosion protection, and is a substantial biointrusion barrier.

Technical Uncertainties

Table 5.2.7-26 shows the application and use of the observational method for the biointrusion barrier. Characterization of local vegetation will aid in determining root growth patterns and will confirm that the volume of soil in the CFD is sufficient to satisfy the needs of the plants growing in them.

Table 5.2.7-27 shows the data quality objectives for each area of technical uncertainty. In brief, the potential deviations will affect the type of top cover used, as well as maintenance requirements.

Performance of Component

The biointrusion barrier of rock over the soil in the CFD will function as desired for the required period. The rock cover will aid in erosion protection, and enhance the longevity of the cell.

5.2.7.3.4 Side Slope Infiltration

Functional Requirements

The infiltration barrier's function is to reduce the infiltration of water to the encapsulated wastes to less than 1×10^{-7} cm/second. The CFD geometry and materials should preclude infiltration to the wastes.

Performance Requirements

The infiltration performance requirements for the CFD are different from those of the cell cover in that the water that percolates through the CFD doesn't come in contact with the waste, but flows down into the foundation soils. Thus, the CFD should control, limit, or direct infiltration into the dikes away from the wastes.

Identification of Alternatives

MVE Table 5.2.7-28 lists three alternative approaches to limiting or controlling infiltration into the wastes with the CFD: a geomembrane on the CFD, compacted clay and silt in the outer layer of the CFD, and random soil. Criteria for evaluating the alternative infiltration barriers are listed in the table. Essentially, the criteria are that the barrier should be simple, durable, and reliable.

Evaluation of Alternatives

MVE Table 5.2.7-28 lists the advantages and disadvantages of the alternative infiltration control approaches. The infiltration control approach with the most significant advantages is the use of the CFD alone, with a geometry and materials that enable infiltration to move essentially vertically downwards through the dike. The CFD is simple to place and cost effective. It will also serve a dual function as a biointrusion barrier. This approach essentially provides no infiltration control, but allows the moisture to flow straight through the CFD (as shown in Figure 5.2.7-18).

The compacted clay and silt layer will provide good infiltration protection, but this is not needed for the CFD. The same is true of the geomembrane. Both of these methods increase expenses and are not necessary to meet performance requirements.

Selection of the Preferred Alternative

An infiltration control approach involving use of only random soil in the CFD is the preferred alternative, because it is cost effective and meets the performance requirements for the CFD infiltration barrier.

Details of the Preferred Alternative

Figure 5.2.7-18 shows a detail of the CFD and shows the flow paths of the moisture that passes through the CFD. It is apparent from the figure that water percolating through the CFD will eventually flow into the foundation soils.

Technical Uncertainties

MVE Table 5.2.7-29 shows the application and use of the observational method to the CFD infiltration barrier. MVE Table 5.2.7-30 shows the data quality objectives for each area of technical uncertainty. In brief, the potential deviations affect the quality and suitability of the soils used in the CFD.

Performance of Component

The CFD infiltration barrier of random soil, protected from erosion by overlying components, will function effectively for the required period. Water seeping into the CFD will not come into contact with the waste, will not be contaminated, and will flow unimpeded and unaffected back into the surrounding environment.

5.2.7.3.5 Stability

Functional Requirements

The perimeter encapsulation system (PES) protects the wastes from dispersal and intrusion. To function effectively, the perimeter encapsulation system must remain stable against static and seismic forces.

Performance Requirements

The PES must remain stable for at least 1,000 years, to the extent reasonably achievable. The slopes and materials of the disposal cell cover shall be no steeper than that required to provide the following safety factors:

Minimum Acceptable Factors of Safety		
Analysis	End of Construction	Long-term
Static	1.3	1.5
Pseudo-static	1.0	1.0

Identification of Alternatives

MVE Table 5.2.7-31 lists four alternative perimeter encapsulation systems. These are shown in Figure 5.2.7-19. They are essentially above- and below-grade cells constructed with and without CFDs. Criteria for evaluating the alternative configurations are listed in the table. The primary criterion is the extent to which they provide slope stability.

Evaluation of Alternatives

Table 5.2.7-31 lists the advantages and disadvantages of the alternative perimeter encapsulation systems. The configuration with the most significant advantages is the partially below-grade cell with a CFD. This approach reduces the height of the cell, provides increased slope stability, and provides a higher factor of safety than non-CFD systems. In particular, CFDs have a high factor of safety because they do not incorporate or place a geomembrane (a low strength layer) near the outer edges or zones of the PES. In addition, the stability of the PES does not depend on the strength of the wastes. The strength of various waste forms (VIT or CSS) is not a factor in the stability of the CFD.

Although the non-CFD approaches are simpler to construct and require less borrowed soil, they have a lower factor of safety against slope failure and their stability depends in significant measure on the strength and configuration of the waste itself. Therefore, more monitoring and control of the waste placement configuration is needed. Also, the liner layers that are low strength are zones or planes of potential instability.

The above-grade cell with a CFD has the advantages of simple construction and good leachate control, but this approach increases cell height, and hence, may result in a reduced factor of safety against slope instability.

Selection of the Preferred Alternative

The stability of the slope of the perimeter encapsulation system depends on the slope angle, the height of the slope, and the strength of the materials in the slope. In particular, the presence of zones or layers of low strength material in the perimeter encapsulation system may negatively affect the stability of the system.

A partially below-grade cell with a CFD is the preferred alternative because it provides increased slope stability and a high factor of safety against slope failure.

Details of the Preferred Alternative

The material for the CFD will be clean-fill, random soil. It will have a slope of 5H:1V. No geomembrane will be used in the dike either at the base or in the upper part of the outer slope. Potential failure is affected only by the strength of the soils and rocks of the dike and its foundation.

Technical Uncertainties

MVE Table 5.2.7-32 shows the application of the observational method to stability. MVE Table 5.2.7-33 shows the data quality objectives for each area of technical uncertainty. In brief, the potential deviations affect the materials used and the design layout. During final design, the material sources and waste volumes will be established and used to determine the exact cell configuration.

Performance of Component

The partially below-grade cell with a CFD with an outside slope of 5H:1V will ensure slope stability and minimize the effects of slope instability and erosion during the cell's 1,000 year design life. Figure 5.2.7-20 shows how the CFD configuration and rock cover details ensure significant slope stability against both static and dynamic forces. As shown in the figure, even in the event of total slope instability, it is highly unlikely the waste containment systems will be breached (*Supporting Study No. 11, Disposal Facilities Seismic Criteria and Assessment*) (Ref. 19).

5.2.7.3.6 Settlement

Functional Requirements

There are no functional requirements associated with settlement because it is an occurrence and not a design. This study addressed the ways to minimize this occurrence. Settlement of the CFD must be controlled and/or minimized to ensure proper functioning of the entire cell.

Performance Requirements

The CFD must perform satisfactorily for at least 1,000 years to the extent reasonably achievable. To achieve this the material of the CFD must remain intact with controlled settlement. Less settlement reduces the potential for cover cracking that could lead to concentrated precipitation runoff flow and greater erosive forces.

Identification of Alternatives

MVE Table 5.2.7-34 lists the two alternative approaches for reducing settlement. They are either constructing the cell above grade or partially below grade. Criteria for evaluating these alternatives are listed in the table.

Evaluation of Alternatives

The settlement for a partial below-grade cell is consistently less than for an at-grade cell; the greater the depth of excavation, the less the cover settlement. This is because excavation reduces the net load on the remaining foundation soils. Further, some of the more compressible foundation soils are removed by excavation and no longer contribute to settlement. Reduced foundation deformation and cell settlement is desirable as the reduced cover movement reduces the potential for:

- Cracking of the infiltration and radon barrier, which may increase the infiltration to the cell and increase the radon flux from the cell.

- Uneven deformation of the uppermost surface of the cover, which may result in areas of flow concentration that increase the erosion potential for a given precipitation event.

Selection of the Preferred Alternative

A partially below-grade cell is selected as the preferred alternative approach to reducing settlement. This is because it reduces the net load on the remaining foundation soils, thus reducing settlement.

Details of Preferred Alternative

See above section, "Evaluation of Alternatives".

Technical Uncertainties

MVE Table 5.2.7-35 shows the application and use of the observational method to settlement. MVE Table 5.2.7-36 shows the data quality objectives for each area of technical uncertainty.

Performance of Component

The partially below-grade cell with a CFD will reduce settlement and perform as desired for the required period.

5.2.8 Cell Drainage/Water Management

5.2.8.1 General. This section addresses collection and control of runoff from the disposal cell during waste placement. Run-on from the area outside of the proposed cell will be prevented by the CFD, so this issue is not further addressed. The drainage design is based on the features of the phased construction of the disposal cell (Section 5.2.6) and the orientation of each disposal cell construction phase (Section 5.2.9). Drainage prior to construction of the LCRS and following placement of the first lift of the cell cover is addressed in Section 5.1.6, Site Drainage.

Drainage Assumptions. The first lift of clean cover material will be placed for each waste placement phase, as the waste reaches the design grade. The LCRS will be designed to handle all rainfall that lands directly on the LCRS prior to the placement of waste (Section 5.2.5). During waste placement, the design storm will be a six-hour event with a 25-year recurrence interval for peak runoff discharge flows and a 24-hour event with a 25-year recurrence interval for flood detention storage capacity (Table 5.1.6–1). The cover and CFD will be designed to handle runoff following placement of the first lift of cover material for each phase, as discussed in Section 5.1.6, Site Drainage, and Section 5.4, Site Closure. Runoff and drainage considerations will generally be the same for both the VIT and CSS treatment alternatives.

Functional Requirements. The drainage system must be constructed to:

- Prevent off-site discharge of runoff that has contacted waste in the disposal cell during and following waste placement.
- Collect and transport contaminated runoff to appropriate locations for subsequent treatment and discharge.
- Facilitate cell construction.
- Protect groundwater quality.
- Protect worker health and safety.

Performance Requirements. During construction the drainage system must:

- Control runoff from the cell to prevent migration off site and to minimize infiltration into native soils.
- Provide for coordination of cell operations with drainage control.
- Provide a drained work area in the disposal cell to facilitate waste placement operations.

During final design, specifications will be developed for the following activities:

- Drainage and erosion control within the cell.
- Runoff collection, detention, and transport to a retention location until the water is treated.

These specifications will be performance specifications with general guidelines regarding methods; actual details will be developed by the subcontractors.

5.2.8.2 Alternatives Evaluation. MVE Table 5.2.8-1 lists the alternatives identified for runoff collection, detention pond locations during Phase I and Phase II operations, and retention locations prior to delivering the water to the site water treatment plant. Criteria for evaluating the alternatives are also listed in the table. Only those alternatives that were considered feasible are included.

Key drainage criteria include the capacity to handle design-storm runoff; the durability of the system; the effectiveness in facilitating and controlling runoff; minimizing disturbance to the cell liner; preventing off-site contaminant migration; and preventing clean areas or materials on site from becoming contaminated. The advantages and disadvantages of each alternative are listed in MVE Table 5.2.8-1.

5.2.8.3 Details of Preferred Alternatives. Figure 5.2.8-1 presents a schematic section of the recommended method of collecting runoff from the placed waste for Alternatives A-A and C-C of cell construction phases, (see Section 5.2.9 for a definition of all the alternatives considered). A low berm of contaminated soil near the toe of the waste will form a drainage ditch, which will be lined with an FML for erosion protection. The berm should be constructed with a smooth sloped ditch bottom so that runoff will drain to the detention locations, rather than following the corrugated effect of the cross slope of the LCRS bays. Any rain falling on the outer side of the berm and any seepage passing though the waste and into the LCRS would be collected at collection points formed by turning up the edge of the Phase I upper FML at the low point of each LCRS bay. A small pump setup will be needed at each collection point to pump the water into the main drainage ditch. Thus, during Phase I work, rain falling in the Phase II area will not contact contaminated waste, so that runoff from this area will not require treatment. The lower FML should also be turned up at the low point of each LCRS bay.

It is expected that there will be essentially no flow on this FML during construction, so that pumps will not be needed. However, the collection points should be monitored periodically to confirm that there is no water or leachate collecting. In addition, the Phase I and Phase II lower FMLs may be connected when the Phase II LCRS is constructed, so that a single collection point exists for the two phases for each bay. The overall pattern for the interface between Phases II and III should be similar to the pattern described for the interface of Phases I and II.

This design will allow collection of all surface runoff during waste placement in the Phase I area before the runoff leaves the area. The collected water will be directed to the retention pond for evaporation or treatment prior to release off site. The drainage ditch will slope gently to the west to the retention pond for Alternative A–A, and to the northeast for Alternative C–C. Small sedimentation basins may be needed along the length of the ditch to trap and remove larger suspended solids that have eroded from the waste pile.

Figure 5.2.8–2 presents a schematic section of the recommended method of collecting runoff at the lower edge of the waste for Alternative D–D, assuming that LCRS bays slope down toward the northwest. This design is simpler to construct and maintain than the methods for Alternatives A–A and C–C, and will be more resilient when subjected to large storm flows. This design also provides a ready-made slope along the length of the channel from south to north. The primary disadvantage is that LCRS bays, which are required (Section 5.2.5), must be oriented approximately parallel to the delineation line between Phases I and II. However, the precise orientation of the edge of Phase I is flexible, and this disadvantage can easily be alleviated by setting the edge of Phase I to match the preferred orientation of the bays. Runoff in the Phase II area will be collected in a similar manner.

Runoff from both Phase I and Phase II should be directed to the Ash Pond Isolation Dike (APID) pond. Initial calculations indicate this pond will be large enough to contain the design storm runoff from the disposal cell (Section 5.1.6.3). The preference is to use this pond unlined, although final design considerations may suggest that the pond be lined with an FML to minimize contaminant infiltration. Sediments may need to be removed periodically from the pond to prevent excessive loss of storage capacity. Because the pond may be located within the final footprint of the CFD, the CFD may have to be constructed with a steeper temporary slope in this region during Phases I and II to allow room for the pond. Details of this temporary slope are discussed in Section 5.2.7.3.

Water would be briefly detained at the APID pond and then pumped to a second location for retention until treatment at the SWTP. The SWTP is sized to treat the runoff from the cell as well as other sources, provided adequate storage capacity is provided at the plant to distribute the demand over time. The primary detention capacity will be provided by the SWTP equalization basin. If and when additional retention capacity is needed, use of Raffinate Pit 2 (following the removal of sludge from this pit) is preferred. The sludge is scheduled to be removed from this pit during the first construction season. After that, water retained there should not become significantly more contaminated than it was when leaving the disposal cell. Water may also be retained in the unlined Raffinate Pit 4 if Raffinate Pit 2 is unavailable or if its capacity is exceeded. Raffinate Pits 2 or 4 could also retain storm runoff if the capacity of the APID pond is exceeded (for example, by back-to-back design storms or if the design storm is exceeded).

As the placed waste approaches the final elevation, drainage should be provided around the perimeter of the waste surface. According to the current design, the edge of the waste pile will slope downward to the CFD (Section 5.2.2). To provide drainage and to protect the CFD from becoming contaminated by runoff from the waste surface, the waste should be sloped away from the CFD for a short distance, as shown on Figure 5.2.8-3. Placement of the initial lift of the final cell cover should begin at the high-point of the waste so that runoff will not flow down onto the clean cover material (Figure 5.2.8-3). Cover placement should progress outward until the edge of the waste is reached. Cover placement should also be sequenced to prevent contaminated runoff from contaminating the clean cover material.

Drainage considerations are essentially the same for both the CSS and VIT treatment alternatives.

5.2.8.4 Technical Uncertainties. For the CSS Alternative, MVE Table 5.2.8-2 shows the results of the application of the observational method to the cell drainage alternatives. Potential deviations from the expected conditions are listed, and the effects of these deviations on the design are noted. The primary uncertainties are related to the actual areal orientations for Phase I and Phase II, the elevation of the cell foundation because of its effects on the potential for gravity flow into the APID pond, and the accuracy of the APID pond topography (and hence storage capacity) (Section 5.1.6.3 for the estimated capacity of the APID pond). The erodibility of soil-like and grout-like CSS products should be studied to evaluate the potential for gully formation and silt generation and their consequences.

As shown in MVE Table 5.2.8-3, data needed to properly assess the technical uncertainties are listed for each area of technical uncertainty. During final design, it will be critical to evaluate the drainage conditions based on the actual cell footprint and the LCRS design grades. It will also be critical to evaluate the storage capacity of the APID pond based on an accurate survey.

Preliminary calculations indicate that the APID pond will hold the construction design storm (Section 5.1.6.4.4). The sides and bottom of the pond could easily be excavated to increase retention capacity, if required. Preliminary calculations also indicate that gravity flow from the edge of the waste placement operation area to the APID pond is possible. However, a final evaluation will be required when the actual cell LCRS grade is determined during final design.

It is possible that a portion of the APID pond will be designated as a wetlands area. In that case, the pond will need to be either maintained in its current condition or, if it cannot be maintained, be replaced in the same or another location. Because of the proximity of the pond to the cell, it is recommended that the pond be used for runoff retention.

For the VIT alternative, the uncertainties and data needs are basically the same as those described for the CSS treatment alternative. However, there are two important differences in drainage considerations:

- The vitrified material will be more permeable than the CSS material. Although the final placed permeability of the vitrified material is unknown, the higher permeability will primarily affect the amount of leachate generated during construction. This increased leachate flow will not exceed the capacity of the LCRS, which will have been sized to handle rain falling directly on it, and direct rainfall runoff will be much greater than any potential leachate quantities.

- The rate of waste placement will be slower under the VIT alternative. Therefore, the cell will be open for a longer period of time, resulting in more winter shut-downs during cell construction. This situation should be accounted for during final design to adequately size retention and treatment facilities.

5.2.9 Operation and Maintenance During Cell Construction

5.2.9.1 General. This section addresses the operations and maintenance activities within the disposal cell during construction. Operations related to construction of the cell liner, placement of waste, cover, and clean-fill dikes, are addressed in Section 6.2. This section addresses the following items:

- Conceptual design of traffic patterns within the cell, as well as construction and maintenance of corresponding access routes within the cell.
- Conceptual design of dust control measures within the cell.
- Sequencing and coordination of waste placement and other operations within the disposal cell.
- Maintenance requirements associated with all of the above.
- Measures to be taken in advance of severe weather.

Functional Requirements. The cell operations and maintenance design must:

- Facilitate cell construction.
- Protect air, surface water, and groundwater quality.
- Protect worker health and safety.

Performance Requirements. During construction, the cell operations and maintenance plan must:

- Coordinate all waste placement operations.
- Coordinate waste placement operations with drainage control systems.
- Control air emissions.
- Facilitate access into and within the cell.
- Accommodate variability in the waste stream.
- Facilitate waste placement operations.

During design work, specifications addressing the following activities will be developed:

- Cell operations.
- Cell maintenance.

These documents will be performance specifications; actual details will be developed by the subcontractors.

5.2.9.2 Alternatives Evaluation. Alternatives were evaluated in an MVE session entitled *Integrated Schedule for Excavation, Treatment, Placement, and Cell Construction* (Ref. 71). Recommendations were developed regarding the number of cell construction phases (one, two, or three phases, or microphases; see also Section 5.2.6), the number of shifts (one, two, or three) for processing and placing the CSS treated product as well as other operations, the sequence of raffinate pit excavation, and overall scheduling. The effects of the lower production rates for the VIT alternative were also discussed. A summary of the schedule of activities developed during the MVE session is shown on Figure 5.2.9-1 for CSS and Figure 5.2.9-2 for VIT.

In addition, a series of informal (one-person) MVE evaluations were performed. MVE Table 5.2.9-1 lists the alternatives for Phase I and Phase II configurations, access locations into the disposal cell, and access road surfacing. Criteria for evaluating the alternatives are also listed in the table. In general, only alternatives that were considered feasible are included in the table.

Key criteria include facilitating cell construction, road surface performance, minimizing contamination of clean cell materials, controlling dust, and protecting subsequent phases of the cell. The advantages and disadvantages of each placement strategy and criteria used to evaluate the alternatives are listed in MVE Table 5.2.9-1.

Traffic patterns for waste placement are discussed in Section 5.2.6. The configurations for Phase I and Phase II are discussed in Section 5.2.8.

5.2.9.3 Details of Preferred Alternatives. For the CSS alternative, a three-phased cell construction program is preferred: Phase I and Phase II for construction and Phase III for closure. The potential orientations for Phase I and Phase II were evaluated, as

documented in MVE Table 5.2.9-1, Items 1 and 2. The alternatives for the Phase I layout are shown on Figure 5.2.9-3, and the top three alternatives are discussed below. Under Alternative A-A, Phase I occupies the southern portion of the disposal cell; this is the orientation that has been assumed during much of the CD work. In Alternative C-C, Phase I occupies the southeast portion of the disposal cell, and in Alternative D-D, Phase I occupies the east portion of the disposal cell.

For Alternatives A-A and D-D, the edge of Phase II is parallel to the edge of Phase I, as shown on Figure 5.2.9-4. For Alternative C-C, the edge of Phase II will be the same as that of Alternative A-A. This configuration will provide a more efficiently shaped closure phase. The less-preferred alternatives (B-A, B-B, and E-E) were not carried into Phase II evaluations.

The MVE session for these alternatives included criteria relating to cell operations and maintenance, as well as cell drainage. Based on the MVE results, all three alternatives are considered equally viable, but Alternative A-A was retained as the preferred alternative primarily because it reflects the layout assumed for much of the Supporting Study and CDR work. However, it should be noted that Alternative D-D has some distinct advantages, particularly with regard to the simplified drainage collection system (see Figure 5.2.8-2).

Further evaluations should be performed during final design prior to selecting the preferred alternative. Changing the drainage collection alternative should not affect other task recommendations, which are based on the Alternative A-A assumption. Although drainage, roads, and traffic patterns will all change significantly, the adjustments will not require reworking the basic assumptions.

A detailed schedule for disposal facility operations may be found in the *Cost and Scheduling Document* of this *Conceptual Design Report*. For the CSS Alternative, the first two phases will be sized to contain the lower bound of waste volume estimated for the disposal cell (1.0 million cu yd), and the closure phase would be sized to contain the current contingency volume (0.5 million cu yd). The CSS product should be produced and placed during two shifts per day. (During final design, CSS processing considerations may result in the decision to produce and place CSS over three shifts per day.) The two-shift operation will significantly shorten the waste placement time and improve the efficiency of the CSS plant by reducing shut-down and start-up time. Both the two-shift and three-shift alternatives accommodate the variations in sequencing of waste removal and CSS plant production rates.

The preferred alternative for access to and hauling within the cell area is recommended below. For Alternative A–A, access to Phase I of the cell is provided by two haul roads over the constructed west clean-fill dike, as shown in Figures 5.1.5–1 through 5.1.5–7. Access for Phase II is similar. If the access location is near the north end of Phase I, the same ramps could be used for both phases; or, if preferable, a new pair of ramps could be constructed in a location more convenient to Phase II operations. For Alternative C–C, access during Phase I will be through the designated Phase II area, and access to Phase II will be over the west clean-fill dike. For Alternative D–D, access during Phase I will be through the Phase II area. Access during the beginning of Phase II may be through the designated Phase III (closure phase) area; however, once construction of the clean-fill dike for the closure phase has begun, access will be over the clean-fill dike, either from the south, north, or both.

A ramp over the clean-fill dike from the east would provide clean access to the top of the cell for construction of the initial cover lifts, as shown in Figures 5.1.5–1 through 5.1.5–7. Water control during construction of the initial cover layer is discussed in Section 5.2.8.

Most haul routes within the disposal cell should be unpaved. The surface course may be soil or CSS product. For portions of the haul routes that will remain in service for an extended period of time, a gravel traction course, a few inches thick, may be required to minimize problems following rain.

Actual access routes and road surfacing should be selected and designed by the subcontractor in charge of waste placement and approved by the PMC.

Dust will be controlled primarily by using water sprayed from a water truck or water wagon. To minimize leachate generation, the minimum amount of water required to control the dust will be used. To minimize the amount of water needed, a dust suppressant, such as magnesium chloride, calcium chloride, or a polymer, may be added to the water. These substances are not anticipated to adversely affect the leachate or the LCRS integrity; the potential for adverse effects will be considered in selection of LCRS materials (Section 5.2.5). Treated water from the site water treatment plant or contaminated water from storm retention ponds may also be used for dust control purposes, as long as contaminated water is not used in clean areas. Trucks will need to be decontaminated before subsequently being used in clean areas.

The site should be maintained at all times to handle normal inclement weather. If heavy rains hit the site, operations will likely need to be shut down because of considerations for traffic safety and moisture control. If particularly severe weather, such as a tornado or a lightening storm, is advancing toward the site, the potential hazard should be evaluated. Operations may need to be halted and equipment parked prior to deciding whether to evacuate personnel from the site. The primary consideration should be protection of worker health and safety. Severe weather is not expected to result in a release of contaminated materials to the environment. Normal drainage control measures should limit erosion of the waste pile to a minimal amount that will not seriously impair cell construction or waste placement.

Operations and maintenance considerations are basically the same for both the CSS and VIT treatment alternatives.

5.2.9.4 **Technical Uncertainties.** MVE Table 5.2.9–2 shows the results of the application of the Observational Method to the evaluation of cell operations and maintenance alternatives. Potential deviations from the expected conditions are listed, and their effects on the design are noted. The primary uncertainties are the actual orientation of Phase I and Phase II and the traffic loading (types of equipment, frequency of trips) on the haul roads. Another uncertainty is that the extent of contamination and of wet or unsuitable soils between the corner of Raffinate Pit 3 and the disposal cell is still unknown. The results of studies in this area should provide additional input to the final decision of the Phase I and Phase II orientation. Finally, the selection of a suitable location for performing major maintenance and repairs of waste placement equipment is another uncertainty.

Data needed to properly assess the technical uncertainties are listed for each area of technical uncertainty on MVE Table 5.2.9–3. During final design, it will be necessary to know the actual configuration of Phase I and Phase II and the anticipated equipment traffic loading data.

5.3 Treatment and Processing

5.3.1 General

The remediation program for the site includes the treatment and processing of selected contaminated waste media. Treatment and disposal of the wastes will protect human health and

the environment through the immobilization and stabilization of the waste and disposal in an on-site engineered disposal cell. In the *Feasibility Study* (Ref. 1), treatment and subsequent on-site disposal of the site wastes was selected as the preferred method over off-site disposal or other alternatives. Wastes include low-level radioactive and toxic materials from the chemical plant area, the quarry, and vicinity properties. These wastes include sludge, soil, water, and rubble. Waste characterization is discussed in Section 2.

The *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 3) determined that the preferred treatment alternative for contaminated soil from certain quarry soils, and certain other contaminated soil from the site, is chemical stabilization/solidification (CSS). Vitrification is being retained as a contingency treatment option in the event that CSS does not perform adequately during pilot-scale testing. Bench scale testing of CSS has given very satisfactory results such that the likelihood of implementing the contingency treatment is remote. Vitrification is being carried forward into the conceptual design phase but will not be costed nor scheduled. Neither will the vitrification be developed further into pilot scale testing at this time. The disposal cell conceptual design was developed using both the CSS and vitrification scenarios.

The treatment and processing conceptual design includes an analysis of the following processes: Chemical Stabilization/Solidification in Section 5.3.2, Vitrification in Section 5.3.3, Size Reduction in Section 5.3.4, Dewatering in Section 5.3.5, Decontamination in Section 5.3.6, and Additional Treatments in Section 5.3.7. The types, quantities, and characteristics of the wastes are addressed below. Additional information from previous studies may be obtained from the reports listed in the Appendix.

Contaminated water on site will be treated in the site water treatment plants. Rubble will be size reduced and placed in the cell. The selected soils and sludge, the largest portion coming from the raffinate pits, and possibly selected containerized wastes will be treated and processed by one of two methods: CSS or VIT. The *Engineering Analysis of Remedial Action Alternatives Phase I/II* (Ref. 48 and Ref. 49) determined that these methods result in the immobilization and stabilization of the wastes. The CSS process produces either a grout product that sets to form a solid monolithic product, or a soil-like product. Vitrification produces a fritted glass-like product. Both products are sufficiently solid and stable to provide the necessary structural stability within the disposal cell (Ref. 58). The wastes are thus immobilized so that radioactive

and hazardous materials are contained. The deterioration or erosion of the product placed inside the cell will be less than if the product were to remain outside.

The wastes and their locations at the Weldon Spring site are discussed in Section 5.1.2, Waste Removal. For the purposes of this discussion however, processing is restricted to those wastes considered for potential decontamination and release, dewatering necessary for further processing, and size reduction to facilitate handling, treatment, or decontamination of wastes. Treated wastes (those treated by CSS or VIT) include raffinate sludge, raffinate pit clay bottom, Building 434 wastes, quarry waste soils, nitroaromatic-contaminated surface soils, and selected spoils pile soils from Ash Pond and other areas. There is a considerable volume of radioactive soil and construction debris that does not require treatment and processing prior to disposal.

5.3.1.1 Waste Characterization. The estimated quantities of waste requiring treatment by CSS or VIT technology are listed below. This table does not include Building 434 wastes.

Material	Volume (yd^3)	Density Wt.* (g/mℓ)	Tonnage	Dry Tons Before Treatment
Pit 1 Sludge	17,400	1.19	17,600	4,700
Pit 2 Sludge	17,400	1.22	17,600	4,700
Pit 3 Sludge	129,400	1.20	130,700	35,000
Pit 4 Sludge	55,600	1.18	56,100	15,000
Pit 1 Clay Bottom	2,440	1.52	3,709	3,000
Pit 2 Clay Bottom	2,440	1.52	3,709	3,000
Pit 3 Clay Bottom	16,800	1.52	24,000	20,000
Pit 4 Clay Bottom	30,000	1.52	45,600	35,600
Quarry Sludge	4,100	1.40	5,740	4,640
Quarry Soils	50,000	1.52	76,000	59,000
Miscellaneous Surface Soils	6,100	1.52	9,272	7,076
Water Treatment Plant Sludges	3,600	.94	3,400	910
Totals	334,280		393,430	191,626

*Source: (Ref. 78)

Table 5.3.1-1 describes raffinate mineralogic and chemical characteristic of the raffinate sludge in Pit 3.

5.3.1.1.1 Raffinate. The raffinate sludge is a product of the lime-neutralized nitric acid and other waste streams that emanated from the Weldon Spring Uranium Feed Materials

Plant which operated from 1957 through 1966. The sludge is composed of very fine-grained silica and other insolubles associated with the yellow cake ore feed materials, along with metal hydroxides and other precipitates formed during pH neutralization. The fine-grained sludge has a relatively high moisture content, averaging about 73% water by total weight.

Chemical contaminants include inorganic ions (nitrate, sulfate, phosphate, fluoride, and chloride), numerous metals, and metalloids (arsenic, cadmium, chromium, and selenium). Radiological contaminants include the radionuclides of the uranium and thorium decay chains. All contaminants were analyzed by Waste Technology Group and Chen-Northern Inc.; the x-ray analysis shown below was conducted by Chen-Northern, Inc. in 1986.

Mineral		Range
Quartz		13-24%
Bassinite*	$CaSO_4 \times \frac{1}{2}H_2O$	24-43%
Sellaite	$Mg F_2$	16-72%
Uraninite	UO_2	21-50%

* May actually be Gypsum ($CaSO_4 * 2H_20$)

Physical Summary:	Pit 1	Pit 2	Pit 3	Pit 4
Impoundment area (acres)	1.2	1.2	8.4	15
Residue depth (ft)	9.25	9.81	9.53	1.25
Ponded water depth (ft)	4.0 (varies)	4.0 (varies)	3.7 (varies)	8.8 (varies)
Solid content (% wt)	27.6	29.4	27.3	25.3
Moisture content (% wt)	72.4	70.6	72.7	74.7
Field laboratory test (% water)	70-75	70-75	70-75	48-52
Wet bulk density (lb/cu ft)	74.4	76.1	75.3	73.9
Ponded water volume (Mgal)	1.56	1.56	9.7	43.16
Interstitial water volume (Mgal)	1.08	1.16	8.22	1.93

5.3.1.1.2 **Raffinate Pit Clay Bottom.** The pit bottoms are most likely composed of clay (Ref. 75) and may be radioactive and chemically contaminated as a result of contact with the overlying raffinate sludge. Although this media has not been characterized, conditions regarding the treatability of this material by CSS and VIT processing can be reasonably estimated. Contaminants of concern likely include arsenic, thorium, and uranium.

5.3.1.1.3 **Quarry Soils and Sludge.** This media consists of a silicious soil and limestone aggregate with both radioactive and organic contamination. Radioactivity is associated with radionuclides of the uranium and thorium decay series. Nitroaromatic and PCB contamination also exists within the quarry soils. Contaminants of concern are trinitrotoluene (TNT) constituents, 2,4-DNT (dinitrotoluene), and nitrobenzene. The results of the *Remedial Investigation for Quarry Bulk Wastes* (Ref. 28) indicate that isolated areas may have 2,4,6,-TNT concentrations up to 2.0%. Although certain organics can inhibit the setting of CSS product, bench scale tests performed by Waste Technologies Group (1992) (Ref. 32) show the nitroaromatic waste can be successfully solidified and stabilized. Additional water may be required for full cementitious mineral hydration. There are no apparent limitations when vitrifying these materials. The average particle size delivered from the temporary storage area is expected to be less than 6 in.

5.3.1.1.4 **Surface Soils.** The surface soils consist of loess, silty clay, and clayey silts (Ref. 76). Riprap and crushed stone aggregate also have been placed for erosion control and site roads, and those may be incorporated with surface soils. The range of percent water of excavated soils is estimated to be between 12% and 20%.

5.3.1.2 **Major Components of Treatment and Processing.** Treatment and processing encompasses CSS, VIT, size reduction, dewatering, decontamination and additional treatments. The CSS and VIT processes involve the treatment of wastes to sufficiently alter their physical and chemical characteristics to allow land disposal.

The CSS process described in Section 5.3.2 will immobilize the contaminants that comprise the RCRA component of Weldon Spring waste. The resulting CSS product will then be only a radioactive waste. Based on the results of laboratory testing and the physical characteristics of the site wastes to be treated, CSS of the site waste media is expected to produce various types of solidified products. Some of these alternatives are listed below:

(1) A grout-like product that sets to form a monolithic product produced from a mixture of:

- Raffinate @ 70%-75% water - Fly ash - Cement - Additives (if needed)	OR	- Quarry soils - Fly ash - Cement - Additives (if needed)	OR	- Surface soils - Fly ash - Cement - Additives (if needed)

(2) Soil-like product produced from a mixture of:

- Raffinate @ 70%-75% water content
- Cement
- Fly ash
- Surface soils, raffinate pit dikes, clay bottom, or quarry soils
- Additives (if needed)

(3) Soil-like product produced from:

- Clay
- Sorbent (fly ash)
- Binder (if needed)
- Additives (if needed)

Because the clay beneath the raffinate pit sludge has not been characterized, the physical and chemical characteristics of this material are not known. If the clay bottom material passes the toxic characteristic leaching procedure (TCLP) test, this material may be treated by adding a sorbent/binder (if needed) prior to placement in the disposal cell. TCLP data to date indicate the raffinate sludge is not RCRA characteristic waste on a pit-by-pit composite basis. Discrete sludge samples, however, have failed the arsenic toxicity characteristic (TC) level. With the exception of more highly nitroaromatic contaminated soil from the quarry, TCLP soil analyses indicate the soils to be disposed of are not RCRA characteristic wastes (Ref. 77 and Ref. 32, and 1992 WSSRAP sludge and near surface chemical soil TCLP results). The major components of the CSS waste treatment process are shown on Figure 5.3.1-1.

Section 5.3.3 discusses the rationale for selecting a vitrification plant operation. A single vitrification operation, producing a single vitrified glass product, is considered adequate for processing all wastes requiring treatment. The vitrification plant produces a glass-like product

that immobilizes contaminants, including radionuclides. Volatile organic compounds that may be present in portions of the waste will be volatilized during the process. It is assumed that the wastes will be totally dried prior to treatment. While vitrified product can be produced in various forms, it has been concluded that a fritted glass, with physical properties similar to a washed sand, will provide the most desirable properties for land disposal. Such material is easily handled and placed with conventional earth moving equipment and will provide an excellent material for minimizing voids among the construction debris placed in the cell.

Section 5.3.4 evaluates the need to size materials for decontamination or handling and placement in the disposal facility. Debris and rubble will be placed in the disposal facility with minimal further size reduction beyond that required for demolition. Concrete rubble will be sized to minimize difficulties in handling and placement in the disposal facility.

Section 5.3.5, evaluates the processes necessary to dewater the raffinate sludges and other wastes to levels compatible with the treatment plant requirements. Because of the extreme range and variability of the water contents of the sludge, and the effect of dredging on the moisture content of the raffinate sludge, the sludge must be pretreated prior to treatment. For vitrification, a nearly dry feed material is required. For CSS, the moisture content of the feed material depends on the product desired, but as a rule, the less moisture in the waste, the less CSS product volume as a result of reduced binder volume.

Decontamination, Section 5.3.6, considers the benefits of removing contaminants from demolition debris and releasing materials off site. Only a relatively small quantity of structural steel may be feasibly decontaminated for unrestricted use. The decontamination facility is proposed to test the feasibility of performing this operation on a production scale.

Additional Treatment, Section 5.3.7 discusses methods available for treating the relatively small quantities of containerized wastes (RCRA and TSCA-mixed waste) that are stored in Building 434. Disposal off-site of small quantities of listed RCRA wastes has also been considered. Water treatment plant sludges are also considered in this section for possible treatment prior to disposal.

5.3.2 Chemical Stabilization/Solidification

5.3.2.1 General. Research has demonstrated that certain contaminants may be immobilized through both chemical and physical processes. For example, transition metals may react with pozzolonic reagents to form relatively insoluble hydroxide species. Other contaminants may be incorporated into the cementitious mineral lattice.

The CSS treatment process will immobilize the contaminants of concern so that the sludge and soils to be treated will consistently pass TC regulatory levels and achieve placement criteria. The application of CSS technology at other sites has demonstrated that the product quality is strongly influenced by:

- Proper reagent selection.
- Accuracy of reagents and waste addition.
- Thoroughness of reagent and waste mixing.

To date, CSS technology has been selected for use at 63 Superfund sites (Ref. 79) to treat a variety of hazardous wastes. CSS technology is also widely used to treat low-level radioactive wastes generated at nuclear power plants nationwide. A variety of reagents are available to attenuate various contaminants.

The U.S. Environmental Protection Agency (EPA) considers CSS a proven remedial technology indicating that further technological development is not required prior to its implementation. However, site-specific optimization of the system design, based on waste characteristics, is still necessary. The alternatives being retained for further consideration are consistent with EPA's preference for remedial action alternatives which emphasize treatment as a major component.

5.3.2.2 Functional Criteria. The functional requirement of the CSS plant is to produce a product that immobilizes the RCRA components (characteristic wastes) of the selected site wastes. The resulting CSS product will significantly reduce the mobility of both the RCRA and radioactive components of materials treated.

5.3.2.3 Performance Criteria. The production rate of the CSS facility must accommodate a schedule that is consistent with overall project objectives and is interdependent

with waste excavation and waste placement activities. Performance criteria require that the CSS plant shall be capable of treating raffinate sludges, soil, clay bottom, quarry soils, and possibly selected wastes drummed and stored in Building 434. The product must be capable of encapsulating other non-treated waste (equipment and demolition rubble) placed directly in the disposal facility. The plant will need to accommodate a wide range of moisture contents and material variability. The plant must be capable of producing both grout-like (monolithic) and soil-like products. The monolithic product shall have a minimum unconfined compressive strength of 50 psi (ASTM D1632-87), and the soil-like material must be structurally stable when placed within the cell. The monolithic product will likely need a waiver (in the *Record of Decision*) with respect to the paint filter tests required by the RCRA's 40 CFR 264.314 and that are used to determine whether a material releases free liquids. A waiver may be needed because the grout loses its fluidity if the water content is not kept high enough so that the grout can flow or be pumped into the voids of demolition debris.

5.3.2.4 **Regulatory Concerns.** The CSS facility will comply with all Federal, State, and local regulatory requirements and DOE orders. After plant operations cease, the facility will be dismantled, and depending on the degree and type of radioactive contamination, will either be disposed of in the on-site cell or decontaminated and taken off site for further use.

The CSS process involves mixing wet raffinate sludge, raffinate pit clay bottom, or soils with Type II Portland cement and ASTM Class F or C fly ash within an enclosed system. Mixing the raffinate may release radon, which will be adsorbed and held until largely consumed by radioactive decay. The efficiency of the pollution control systems will be continuously monitored. Ambient air in the CSS facility building will be monitored for potential air contaminants to alert operators to potential system failures and unsafe contaminant concentrations.

Continuous air sampling will be conducted at the site perimeter to evaluate compliance with the National Emission Standards for Radionuclide Emissions from Department of Energy facilities and other State and Federal ambient air standards. The air monitoring stations will detect changes in air quality caused by site activities.

The facility will not discharge water under normal operating conditions. Therefore, ambient water quality will not be impacted, and the facility will not require discharge permits. Water collected on site from washdown of equipment or other decontamination activities will

be collected and used in the CSS process. Excess water that accumulates under unusual operating conditions will be transferred to the site water treatment plant for treatment. The water treatment plant will discharge to a holding pond where the water will be tested for compliance with the existing site NPDES permit before it is discharged.

Regulations promulgated under the RCRA (40 CFR 268) require the CSS product to be treated below applicable treatment standards prior to land disposal. As part of bulk waste characterization, TCLP testing will be performed on waste components to be treated by CSS. Based upon characterization and pilot plant results the need for TCLP testing of the CSS product will be evaluated.

5.3.2.5 Plant Design and Process Components. The plant shall be designed to be consistent with the functional and performance criteria presented in Sections 5.3.2.3 and 5.3.2.4. Operation considerations for the conceptual design are presented in Section 6.3.2.

- Material Balance. Material balancing reconciles the feed rates (input) of waste and binders with CSS production rates (output) of treated waste. The material balance for producing grout-like (monolithic) and soil-like products are shown on Figures 5.3.2-1 and 5.3.2-2, respectively. Section 6.3.2.3.5 discusses the operation requirements that determine the design upon which the material balance is based. The material balance is based on Waste Technology Group bench test results presented in Table 5.3.2-1. The primary mixer ensures uniform distribution of moisture and binder throughout the mix. The secondary mixer provides contact time for the binder and waste particles. Optimization studies are continuing and will impact material balance estimates.

- Additional Engineering Analysis. The pumpability and dewatering processes of raffinate sludge have yet to be fully defined.

  The clay bottom processing will be analyzed with respect to TCLP testing and physical characteristics.

  Pilot-scale testing and analysis will be performed on the binder - mixing of cement and fly ash; binder and raffinate sludge; and binder and raffinate sludge in combination with quarry soils, site soils, or clay.

Radon emanation studies must be conducted for all mixing and transfer processes, including all vents (filtered or not filtered).

- Human Interface and Influence on System Design. Operating employees must be protected against any physical or respiratory contact with processed waste or stabilized product.

  The plant will be designed to minimize the possibilities of material spills and dust emissions. The waste loading points open to the atmosphere will be equipped with dust suppression systems. The material handling equipment, such as conveyors, is assumed enclosed and equipped with efficient belt cleaning systems. The feed and mixing system will be sealed to prevent the spill of dry or liquid binders or waste.

  All equipment with a dynamic effect on the support structure or connected to piping and other equipment must be placed on isolators. System safety features will not eliminate the requirement for use of Level C personal protection by workers. The plant system must be designed to allow self-cleaning, gravity discharge, or forced emptying of all equipment that handles treated or untreated waste before maintenance or disassembly.

- The CSS process consists of two production capabilities:

  - CSS plant - producing both grout-like and soil-like product processing raffinate, quarry soils, and surface soils with the binder.

  - Parallel plant - producing soil-like product processing clay with fly ash.

- Component Design. The CSS plant is currently designed for the following production:

  - Design production: approximately 100 tph.
  - Actual production: 80 tph.
  - Minimum capacity: 55 tph.

The operation of the CSS plant is estimated as follows:

Two shifts/day; first shift: 8 hours of continuous production.
second shift: 6.5 hours of continuous production and 1.5 hours for discharging, flushing, and cleaning.

Five days/week, nine months/year

The parallel plant processing clay liner material with sorbent is designed for the following capacity:

- Design production: approximately 100 tph.
- Actual production: 80 tph.
- Minimum capacity: 55 tph.

The parallel plant operation is estimated as follows:

One shift/day, daytime only: 8 hours of continuous production; no cleaning required.

Five days/week, nine months/year

Figure 5.3.2-3 shows the related processes and the effective and total time needed to adequately supply the CSS facility.

The estimated total production of the CSS and parallel clay bottom processing plants is 484,000 tons. This will take approximately 28 calendar months.

The process diagram shown on Figure 5.3.2-4 illustrates the combination of the components listed below.

- Material preparation
  - Quarry soil, surface soil, spoils pile soils (if applicable).
  - Clay bottom (limited to low-moisture-content clay < 10% water content)

- Components storage
  - Cement
  - Fly ash
  - Additives (if required)
  - Water
- Waste storage
  - Raffinate sludge storage
  - Clay
- Radon adsorption
  - If required in CSS
- Production plant
  - Feed system
  - Mixing system
  - Discharge system
- Production plant for clay processing
  - Direct feed by material handling
  - Mixing system
  - Discharge system
- Control system
- Electrical system
- Structural system

The preferred design for an elevated plant is shown on Figures 5.3.2-5 and 5.3.2-6. The production plant consists of a feed, mixing, and discharge system. Access from ground level is by stairway to any level. Beneath the facility is a waste and water collection sump with a

pump that recycles the spill back into the process. The control system is located in an enclosed room equipped with an air purification system and a process computer.

5.3.2.5.1 Reagents. CSS technology commonly uses Portland cement, fly ash, soluble sodium, and potassium silicates, hydrated lime, quick lime, gypsum, bentonite, zeolites, cellulosic sorbents, contaminant-specific attenuating chemicals, or proprietary compounds as contaminant immobilizing reagents. Based on laboratory testing by WTG and on-site bench testing, Type II Portland cement and ASTM Class F or C fly ash are reagents most likely to be used. Other reagents, such as antifoaming agents, and accelerating or decelerating setting agents were not tested.

The selection of the specific type of Portland cement is a function of sulfate content of the waste to be treated, the time required to develop strength, and the maximum tolerable heat of hydration. Selection of the optimum Portland cement type for the Weldon Spring site wastes is based largely on sulfate tolerance. The waste contains relatively high levels of sulfate, necessitating a sulfate-resistant cement, such as Type II. Detailed evaluation of the alternatives is discussed in Section 6.3.2.3.3.

5.3.2.5.2 Material Preparation. The materials requiring treatment are described in Section 5.3.1.2. Depending on the material characteristics, various material preparation operations may be required to produce a feed material that is acceptable to the processing plant. The two most influential characteristics are material moisture content and particle size. Moisture content affects material handling as well as the actual stabilization process. Particle size must be within limits of handling and processing equipment requirements. The limited on-site testing indicates that raffinate sludge has 70% to 75% water content. Under these conditions, the sludge is pumpable. Excavated soil is estimated to contain 12% to 20% water and 20% to 40% clay-sized material. Quarry soil stored at the TSA is estimated to contain 5% to 15% water. The water content of contaminated stockpiled soils in the Ash Pond area and potentially contaminated spoils pile soils located north of Raffinate Pit 2 is estimated to range from 15% to 25%.

Excavated soil, quarry wastes from the TSA, and selected contaminated stockpiled soil may contain larger sized material, including stones and rubble. The practical limit on maximum particle size for mixing purposes is 2 in. The moisture content of these materials is suitable for production of the CSS soil-like product (Figure 5.3.2-7). A separation process using a vibrating

grizzly and screens is assumed to be required. Oversized separated soils will be washed and transported to the disposal facility without further processing. This material is not expected to exceed 3% of the total soil waste volume. Material can be conveyed by enclosed belt conveyors, chain conveyors, or screw conveyors. Due to the relatively low moisture contents of the materials, all transfer points should be dust suppressed. The storage pile is assumed covered to provide production reserve during wet weather and for radon control and removal, if required. A minimum 500-ton storage will be necessary to ensure the supply of dry plant feed is uninterrupted by rain. The justification for covering the pile will be determined in pilot test operation.

Due to the high moisture content of the raffinate sludge, the only preparation required before treatment will be pumping and storage. This material will be used to produce the grout-like product (Figure 5.3.2-8). The raffinate is stored in vertical tanks with conical bottoms where it will be continuously mixed by high-speed pumps to prevent plugging of the system.

5.3.2.5.3 Radon Emission Control. The proposed radon emission control system designed for the CSS process is only applicable within an enclosed system that prevents radon from escaping into the atmosphere.

The proposed control system is composed of two independent circuits: a primary gas pressurized circuit with dynamic adsorption and a secondary circuit for static adsorption and decay of radon daughters. The primary system operates continuously, balancing the headspace gas from the raffinate storage tanks by compression and expansion. The purpose of the secondary circuit is to treat/decay the volume of storage headspace gas which exceeds the capacity of the primary circuit. A functional diagram of the radon emission control system is presented in Figure 5.3.2-9. This system is discussed in detail in Section 6.3.2.3.3.

5.3.2.5.4 Component Storage System. Component storage consists of a vertical bin system. Both binder components, cement and fly ash, are pneumatically fed and discharged. Two system alternatives are available. The first alternative consists of delivering each binder component separately to the feed bin. The second option involves mixing both binder components in dry form and storing the mixture in a feed bin. Premixing the binders will reduce the required product mixing time. This system is illustrated in the functional diagram presented in Figure 5.3.2-10 and is the alternative selected for conceptual design. The detailed evaluation of the storage system alternatives is presented in Section 6.3.2.3.3.

5.3.2.5.5 Feed System. The proposed CSS plant will have feed systems for the following feed materials:

- Cement
- Fly ash
- Binder (cement and fly ash)
- Raffinate sludge
- Soils
- Water (if required)
- Additives (if required)

Two feed system alternatives have been identified. Both involve modifying only a portion of the feed system in the cement and fly ash feed areas. The first alternative, shown on Figure 5.3.2-11, consists of using a mechanical feed system of screw feeders. Solid material and raffinate sludge is pumped directly from the storage tank. Water and the optional additives will also be pumped to the CSS process.

The second alternative is a combination of pneumatic material handling for pre-mixed binder (fly ash and cement), and a mechanical feed system for raffinate sludge and soils as shown on Figure 5.3.2-12.

5.3.2.5.6 Mixing and Product Discharge System. The proposed mixing system may consist of two independent installations: the CSS plant and the parallel plant for processing clay liner bottom material. The CSS plant will consist of a high shear mixer (high-speed type), operating in batch mode. The pug mill, located in series, is used for additional mixing. With this design, it is possible to produce either the grout-like or soil-like product. The grout-like product is gravity discharged into the other pump sump and pumped into an elevated truck loading bin. The soil-like product is conveyed into a elevated truck loading bin.

The parallel plant (Figure 5.3.2-13) is proposed for generation of a soil-like product made from raffinate pit clay bottom and fly ash. The clay feed into the pug mill is assumed to be by front-end loader. The plant consists of one pug mill, located in the vicinity of the CSS plant and binder storage bins. The soil-like product is conveyed into an elevated truck loading bin.

5.3.2.6 Plant Location. The proposed CSS plant site is in the vicinity of Raffinate Pits 1 and 3, near the southwest corner of the disposal cell (Figure 5.3.2-14). This area is presently occupied by the existing spoils pile north of Raffinate Pit 1.

The road system will provide the access necessary for transporting the waste to the treatment plant, the components to storage, and emptied delivery trucks to the appropriate decontamination station. The dewatering plant is located near the southeast corner of Raffinate Pit 3. Trucking the stabilized waste to the disposal cell is assumed to be via a two-way road with a loop around the CSS plant.

The cement, fly ash, and flocculent (for the dewatering plant) will be delivered by trucks using the access road from the southeast. All trucks will be surveyed for radioactive contamination after delivery. If contamination is detected, the truck will be decontaminated before leaving the site.

5.3.2.7 Specifications. Following is a preliminary list of specifications that may be developed during Title II design.

Category	Title
Mechanical	
	Scalping grizzly
	Vibrating screen
	Belt conveyor
	Screw conveyor
	Washing screen
	Bucket elevator
	Pug mill
	High shear mixer
	Vertical mixing tank (storage)
	Positive displacement pump
	High speed centrifugal pump
	Bolted bin
	Feed hoppers
	Carbon absorber

Category	Title
	Air compressor
	High-pressure tank
	Chemical gas dryer
	Low-pressure tank
	Metering feed pump
	Screw feeder
	Drum pump
	Total mechanical specifications
Civil/Structural	
	Excavation and backfilling for structures
	Concrete reinforcing
	Cast-in-place concrete
	Structural steel fabrication
	Steel joists
	Steel roof deck
	Metal fabrications
	Civil specifications
	Total civil/structural specifications
Electrical/Instrumentation	
	Electrical work
	Power transformer
	Switchgear
	Unit substations
	Motor control centers
	Panelboards
	Lighting fixtures
	Motors
	Grounding
	Heat tracing

Category	Title
	Fire alarm
	Instrumentation work
	Instrumentation index list
	Instrumentation data sheets
	Instrument specifications
	Total electrical/instrumentation specifications

5.3.3 Vitrification Design

Vitrification refers to the heating of waste materials in a melter until they are blended together, followed by cooling of that melt to ambient temperature forming a noncrystalline solid or glass product. During this process, organic constituents (TNT, DNT, TBP) and certain inorganic constituents are destroyed and the remaining nonvolatile inorganic constituents are incorporated into a relatively inert vitreous solid resembling obsidian, a naturally occurring volcanic glass. Certain volatile and semivolatile elements are partitioned within the glass phase and/or captured within the off-gas treatment system.

This section focuses on the conceptualization of a potential vitrification facility to treat selected site wastes. A variety of potential waste blends, waste blending and feeding systems, product discharge, handling and storage systems, and off-gas treatment systems are available.

The conceptual vitrification treatment system presented in this report can process waste materials with varying chemical constituents in varying concentrations, and continuously generate an acceptable product through the destruction or immobilization of the constituents of concern. Results from previous and ongoing vitrification bench-scale test programs have been used to evaluate potential waste blends and the effects of these blends on equipment selection and performance. Selection of one device or waste blend may impact other components within the treatment facility; therefore, the facility should not be regarded as a collection of totally independent pieces of equipment.

This section includes an overview of vitrification technology, performance and functional criteria, regulatory concerns, plant and process components, plant location, and an outline of specifications. The uncertainties related to vitrification of the selected site wastes are also discussed.

5.3.3.1 General. Vitrification is based on physical and chemical principles of glass making. Vitrification is currently being used to treat hazardous substances and is considered the best developed available technology (BDAT) for treating high-level radioactive waste (HLW). Vitrification processes are also being considered for treatment of low-level radioactive and hazardous wastes, but, the process has not been applied on the scale required to treat the site wastes. Therefore, HLW vitrification and glass making technologies served as a basis of selecting equipment for use on the scale required to treat selected site wastes.

The preferred technology for site application is a fossil fuel-heated ceramic melter (FFHCM). The selection of the melter typically drives the selection of the other ancillary, but required, circuits of the system such as the off-gas treatment circuits and to a lesser extent, the feed preparation circuits. Melter technologies and the ancillary circuits that complete the vitrification system are described in more detail in Section 5.3.3.4 and 6.3.3.3.

The temperature at which the waste melts and the quality of the resulting product depend largely on the chemical composition of the original waste. The glasses proposed to encapsulate the site waste contaminants are silica-based glasses. Therefore, silica is one of the required ingredients in the melter feed or waste to be treated. Commercial and high-level radioactive waste glasses typically incorporate varying amounts of alumina, lime, sodium oxide, lithium and boric oxide into the feed mixture to change the physical or chemical properties of the melt or resulting glass. For example, increasing the silica content produces a more durable glass. Increasing the lime content causes the material to melt at a lower temperature, but decreases the resulting glass's durability. It is therefore important to evaluate bench-scale treatability test results to determine acceptable and optimum feed chemistries.

In the glass industry, certain geologic materials are combined to prepare a feed mixture that has the required melting characteristics and produces the type and quantity of product desired. Similarly, waste vitrification requires the proper blend of materials to obtain desired melting conditions and product quality. Bench-scale test results indicate that the wastes at the site can be blended together, without additives, to form a melter feed material with the desired melting characteristics and to produce the product quality required (Ref. 33, Ref. 34, and Ref. 80). Additives, reagents, and waste blending are further discussed in Sections 5.3.3.4.3 and 6.3.3.3.2.

Section 5.3.1.1 lists the types and quantities of selected wastes scheduled for vitrification treatment. In general, these wastes include raffinate sludge (radionuclide and inorganic contaminated), clay bottom material (raffinate sludge contaminated), quarry soils (radionuclide and TNT/DNT), and some miscellaneous soils. Vitrification may also be applied to other wastes such as the radiologically contaminated tributyl phosphate (TBP) or other miscellaneous waste. The quarry water treatment plan and site water treatment plant sludges may require treatment prior to disposal; it is anticipated that these materials can be vitrified. Minor amounts of these wastes will not impact the design capacity of the vitrification facility and will be processed concurrently with the other waste media.

5.3.3.2 **Functional Criteria.** The functional requirements of the VIT plant are the same as those of the CSS plant: to produce a sound product that immobilizes contaminants of concern. The vitrified product will be a non-RCRA radioactive waste and not a mixed waste form. Additionally, vitrification will reduce the volume of waste product and destroy certain contaminants, including TNT and DNT.

5.3.3.3 **Performance Criteria.** The facility must produce vitrified product in sufficient quantity to meet scheduled objectives, including excavation and handling of the wastes and placement of the vitrified material in the cell along with other untreated waste and demolition debris. The VIT treatment plant must be capable of processing the raffinate sludges, soil, clay bottom material, and quarry soils.

The plant must process wastes with varying moisture contents and consistency. The product must pass TCLP criteria. The waste blend will be adequately tested prior to full scale treatment so that only occasional samples will be subjected to TCLP testing as part of the ongoing Quality Assurance/Quality Control Program. The product must be capable of being handled and placed in the disposal cell with conventional earth moving equipment. Once in place, the vitrification product should not cause cell instability or cover distress.

5.3.3.4 **Regulatory Concerns.** The VIT facility will comply with all Federal, State, and local regulatory requirements and DOE orders. After plant operations cease, the facility will be dismantled and depending on the degree and type of radiological contamination, will either be disposed of in the on-site cell or taken off site for further use. All vitrification operations will adhere to the site's *Health and Safety Plans*. The conceptual design also incorporates features such as pneumatic transferral of selected wastes and the use of sealed

systems to minimize air emissions. Additionally, open stockpiled wastes will be kept damp and transported on watered routes to reduce dust.

The facility will not discharge water under normal operating conditions. Therefore, ambient water quality will not be impacted, and the facility will not require discharge permits. Water collected on site from wash down of equipment, waste drying operations, or other decontamination activities will be collected and sent to the site water treatment plant. Excess water that accumulates under unusual operating conditions will also be transferred to the site water treatment plant for processing. The water treatment plant will discharge to a holding pond where the water will be tested for compliance with the existing site NPDES permit before it is discharged. The TCLP, product form, and control of air emissions are discussed separately.

5.3.3.4.1 **Toxicity Characteristic Leaching Procedure.** Passage of TCLP criteria is require for land disposal of WSS waste materials. Vitrification treatment using a 50:50 raffinate sludge to soil/clay blend, a modified variant of this blend, or soil/clay alone will meet the TCLP criteria. The TCLP test reacts a disaggregated sample, with a particle diameter of <0.375 in., with an acetic acid solution for a period of 18 hour. Bench-scale produced vitrified samples can be TCLP tested immediately upon cooling; therefore, the only constraint for conducting the test on vitrified products is the time required to perform TCLP testing.

Previous bench-scale tests prove that a wide range of raffinate sludge to soil/clay will produce an acceptable vitrified product that pass both the TCLP (Ref. 34, Ref. 33, and Ref. 80) and EP toxicity (EP TOX) tests. The vitrification system therefore has greater latitude in operation because of the flexibility in what the melter can accept for feed. The 50:50 waste blend without additives has only been tested by the older EP-TOX test; this test was conducted by Pacific Northwest Laboratory prior to the implementation of the TCLP by the EPA. It is reasonable to assume results of this test are similar to those that would result from a TCLP test of the same material. These EP-TOX results are presented on Table 5.3.3-1 along with TCLP results from tests of the silica phase from other waste blends conducted by the Vitreous State Laboratory of the Catholic University of America (Ref. 80).

This data indicates all of the blends tested to date have passed the TCLP or EP-TOX tests. The data shown are for the glass phase only, which was prepared by blending additives such as Na_2O ($\pm Li_2O$, B_2O_3) at an amount greater than or equal to 10% (wt), with the exceptions of VSL7, tested with TCLP and PNL1, tested with EP-TOX. These results show that

additives are not required to pass these leaching criteria. Moreover, as shown in the Vitreous State Laboratory test results, it appears that the glass samples prepared without additives generally display slightly less leaching than those prepared with additives. The immiscible sulfate phases were assumed by the researchers to probably fail the TCLP and were therefore not tested. Immiscible phases are discussed in Section 5.3.3.4.3 and 6.3.3.3.2.

5.3.3.4.2 **Product Form.** The proposed vitrification system will produce a fritted or water-quenched glass-like product. This product form was chosen because it will generate a granular product that can be easily handled with standard earth-working equipment and can be adequately compacted in the disposal cell. Compaction tests on this vitrified waste form will be required for future design efforts. Placement of this product in the cell is anticipated to be similar to that for other soils, because it can be compacted using similar equipment and methodologies and can be placed in and around disposed equipment and debris to fill voids. This product is rapidly cooled, thereby minimizing immiscible phase formation. However, this product form also has a high surface-to-volume ratio, which theoretically increases the rate at which contaminants can diffuse out of the vitrified form. Calculations indicate, that while this may be the case, retention of these contaminants in the glass product is expected to be measured in thousands, if not millions, of years (Ref. 81). The fritted product represents a large reduction in waste tonnage and volume as shown in the following table.

Waste Minimization Through Vitrification Treatment

Description	Existing Waste	Vitrified Waste	Waste Reduction[a]
Tonnage (Tons)	393,430	192,000[b]	51.2%
Volume (cu yd)	334,280	145,900	56.4%

(a) Reduction in waste tonnage and volume due to removal of water.
(b) Approximately 0.7% to 6% of this amount will be captured in the off-gas treatment system and will likely require further treatment prior to placement in the cell.

Radon is also well retained within the vitrified product (Ref. 34). Previous tests indicate that radon is significantly encapsulated in the glass matrix. This encapsulation is due to the physical encapsulation of radium (a solid) within the glass through mechanisms similar to those for other trace metals. When radium decays to radon (a gas), the radon is contained at the same location as the previously existing radium, until it decays back to polonium and other solid decay

products. The radon has a short half-life (3.8 days) and therefore has little time to migrate by diffusion through the glass in its gaseous form. Encapsulation as described, applies only to radium/radon that is encapsulated within the glass matrix. Radium/radon that occurs at the surface of the glass would not be encapsulated and could escape into the surrounding pore spaces. Therefore, while radon is well retained within the glass matrix of a vitrified product, such retention is not complete and depends upon the spacial distribution of the radium/radon in the glass form, the surface to volume ratio of the glass form, and fractures within the glass form.

Other product forms are possible and the equipment used to generate them could be interchanged within the vitrification system without adverse effects to any other major process circuits of the system. Alternative products include shaped or containerized forms. These products would decrease the surface to volume ratio, but would require additional process circuits in the vitrification system. It is also likely that annealing circuits would be necessary to gradually cool the glass product to mitigate against explosions caused by internal stresses within the glass. Product forms other than the fritted form will require specialized handling equipment and waste placement methodologies.

5.3.3.4.3 **Air Emissions.** The proposed vitrification system is designed to minimize air-borne emissions and meet all applicable air quality regulations. Potential air emissions such as particulates, submicron particulates, acid gases, and combustion products from the vitrification of WSS wastes have been considered. This section addresses only those potential applicable and/or relevant and appropriate requirements (ARARs) that directly affect emissions from the vitrification units; ambient air concentration limits are not addressed. Ambient air ARARs include: National Ambient Air Quality Standards; radionuclide limits set in the Code of Federal Regulations (CFRs), DOE Orders, and Missouri regulations; and any State or Federal acceptable ambient levels for toxic air pollutants. Ambient air ARARS will be addressed during the ambient impact analysis (dispersion modeling).

Resource Conservation and Recovery Act Regulations. RCRA regulations governing the discharge of hazardous materials into the environment are stated in 40 CFR 260 through 271. For this study, the material to be vitrified was assumed to be a "hazardous waste," as defined by the RCRA. Although the material may not be characterized as a hazardous waste, RCRA regulations governing the incineration of hazardous waste are deemed appropriate.

The fossil-fuel heated melter proposed for waste vitrification is an industrial furnace designed to process hazardous waste. RCRA emissions and operation regulatory standards for hazardous waste burned in boilers and industrial furnaces are found in 40 CFR 266, Subpart H.

Emissions Standards. As specified in Part 266.104, Subpart H, an industrial furnace processing hazardous wastes must meet the following criteria:

- The furnace must achieve a destruction and removal efficiency (DRE) of 99.99% for each principal organic hazardous constituent (POHC). Constituents are designated at POHCs based on difficulty to destruct and concentration in the waste.

- Concentrations of carbon monoxice (CO) in the off-gas must not exceed 100 ppmv, over a 60-min moving average. These CO concentration limits could be waved, if the total hydrocarbons (THC) concentration in the stack does not exceed 20 ppmv, reported as ppmv propane in dry gas and corrected to 7% O_2.

- Particulate emissions must not exceed 180 mg/dscm (dry standard cubic meter) or 0.08 gr/ds cu ft (dry standard cubic foot) when corrected to 7% oxygen in the stack gas.

Standards for Toxic Metals and Hydrochloric Acid. Screening limits have been proposed by EPA for heavy metals and hydrochloric acid (HCl). These limits govern feed rates and emission rates. If these rates are exceeded, the operator must demonstrate compliance with reference air concentrations for noncarcinogenic metals and the 10^{-5} risk level for carcinogenic metals using dispersion modeling. The screening levels are listed as a function of stack height for urban and rural areas for either complex or noncomplex terrain.

For noncomplex terrain in rural areas, the feed screening limits for a 30-m stack are:

Antimony	0.95 lb/hr	Barium	168 lb/hr
Lead	0.29 lb/hr	Mercury	0.95 lb/hr
Silver	9.5 lb/hr	Thallium	0.95 lb/hr
Arsenic	0.0026 lb/hr	Cadmium	0.0066 lb/hr
Chromium	0.0010 lb/hr	Beryllium	0.0049 lb/hr
Total Cl	1.3 lb/hr		

Emission screening limits for a 30-m stack are:

Antimony	0.12 g/sec	Barium	21 g/sec
Lead	0.036 g/sec	Mercury	0.12 g/sec
Silver	1.2 g/sec	Thallium	0.12 g/sec
Arsenic	0.00033 g/sec	Cadmium	0.00083 g/sec
Chromium	0.00012 g/sec	Beryllium	0.00061 g/sec
HCl	2.8 g/sec		

Operating Requirements. Fugitive emissions from the combustion zone must be controlled either by keeping the zone totally sealed or by maintaining the zone at less than atmospheric pressure. The melter must be operated with an automated feed cutoff system that activates when operating conditions deviate from those required to comply with emission standards.

Monitoring Requirements. The minimum monitoring requirements for industrial furnaces processing hazardous waste under 40 CFR 266 include the following.

- Combustion temperature, waste feed rate, and combustion gas velocity must be continuously monitored.

- CO, oxygen (O), and possibly THC must be monitored continuously at a point downstream of the combustion zone and prior to release into the atmosphere. This monitoring must conform with "performance specifications for continuous emission monitoring of carbon monoxide and oxygen for incinerators, boilers, and industrial furnace burning hazardous waste" in Appendix IX of 40 CFR 266.

- The melter and associated equipment must be visually inspected daily for leaks, spills, fugitive emissions, and signs of tampering.

- The emergency waste feed cutoff system and associated alarms must be tested weekly.

- Monitoring and inspection data must be recorded and placed in the operating log.

Toxic Substance Control Act Regulations. EPA rules for controlling polychlorinated biphenyls (PCBs) under the Toxic Substance Control Act (TSCA) are presented in 40 CFR 761. Under the TSCA, material containing less than 50 ppm PCBs is not regulated. Because some site waste materials may contain PCBs in concentrations exceeding 50 ppm, the melter will have to meet stringent requirements for PCB incineration if those wastes are to be vitrified. These requirements include long off-gas retention times at high combustion temperatures, a 99.9% combustion efficiency, and DREs of 99.9999%.

Compliance with TSCA regulations would require special design of the melter to ensure long gas retention times. This requirement would significantly increase the cost of design, construction, and operation of the melter, and could result in much greater NOx emissions. Since the amount of PCB-contaminated material to be vitrified is expected to be less than 1,000 cu yd, disposing of this waste by an alternative method would be most cost effective.

National Emission Standards for Hazardous Air Pollutants Regulations. National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations are presented in 40 CFR 61 for specific pollutants and industrial process types. NESHAP standards are applicable to "those sources which process mercury ore to recover mercury, use mercury chlor-alkali cells to produce chlorine gas and alkali metal hydroxide, and incinerate or dry wastewater treatment plant sludge." This standard may apply to the waste stream to be vitrified. The mercury emission standard for incineration of the sludge is 3,200 g Hg/24 hr (0.29 lb/hr).

Missouri State Regulations. Code of State Regulations (CSR) Part 10, Section 10-5.030 limits particulate matter emissions from new indirect heating sources with a heat input greater than 10 million Btu/hour to a value indicated by:

$$E = 0.80(Q)^{-0.301}$$

where E = the maximum allowable emission rate in lbs/10^6 British thermal unit (Btu) heat input and Q = the installation heat input in 10^6 Btu.

Particulate matter from any industrial source is limited to less than 0.30 grain/standard ft^3 of exhaust gas by 10 CSR 10-5.050. This section also requires an 8.3-ton/hr process (200 ton/day) to limit particulate emissions to 17.0 lb/hr, and 10 CSR 10-5.090 limits the opacity of the exit gas to 20%.

Radon. State of Missouri radiological regulations stipulate a 1 pCi/l radon limit for off-site public exposure from operating facilities (CSR 20-10.010 and 19 CSR 20-10.170 *Protection Against Ionizing Radiation*). DOE Order 5400.5, *Radiological Protection of the Public and the Environment* specifies a 3 pCi/l off-site exposure for radon.

Design Issues. Radon control may be required for the raffinate sludge and, therefore, a carbon system may need to be fitted to the raffinate storage silos. Raffinate storage silo radon-bearing air may need to be exhausted through a carbon system, causing attenuation of the radon prior to atmospheric release.

Pneumatic waste transport systems, sealed systems, watered haul roads, and maintaining stockpiled wastes in a moist condition will help to minimize dust emissions.

High-efficiency particulate air (HEPA) filters will be incorporated into the venting systems of waste storage or feed units to protect workers and the environment.

5.3.3.4.4 Double Walled Piping. An analysis of applicable regulations (MK 1991c) indicates that double walled piping will not be required in the plant. The single-wall piping that will be used will only require daily visual inspection.

5.3.3.4.5 Treatment Residuals. The conceptual vitrification facility will generate by-product wastes such as off-gas treatment scrubber blowdown sludges and particulate filtration residuals. However, it is important to note that by-product waste volume is expected to be small. Some residuals may require further treatment; however most will be recycled back into the melter. The following discussion is based on estimated off-gas emissions from expected WSS waste materials and scrubbing efficiencies reported in vendor data for similar treatment systems currently in operation (Ref. 82 and Ref. 83). Anticipated variations in the waste chemistry are not expected to significantly alter the estimated treatment residuals or their handling. However, engineering- and pilot-scale testing of the anticipated fossil fuel-heated ceramic melters (FFHCM) melter morphology, coupled with an off-gas treatment system, is recommended to more accurately estimate these residuals.

HEPA filters, fitted to waste storage silos, will require periodic replacement and will be contaminated with radioactive or hazardous chemical compounds. These materials will be introduced back into the melter as feed and, therefore, will not require additional treatment.

The off-gas treatment system scrubbers have a primary quench scrubber and a secondary aerosol/acid gas scrubber. Solids separated from the primary quench scrubber blowdown slurry are anticipated to approximate the chemistry of the original feed material and will be recycled back to the melter for vitrification. The remaining liquid will be recycled back into the scrubber after treatment. If this liquid/solids separation is not easily accomplished, the entire slurry could be introduced to the melter.

Slurry from the secondary aerosol/acid gas scrubber blowdown will require treatment prior to disposal; therefore, a liquid/solid separation of this slurry will be required. Solids from this separation will require disposal as waste, because the elevated concentrations of volatile metals prohibit recycling back into the melter. It is possible that this material, or a portion of it, may be recycled into an oxidizing region of the melter. Research is underway by one FFHCM vendor to determine likely amounts of volatile metals that can be recycled in such a manner. Such recycling would mimic the concept of cold-top melting used by some joule-heated ceramic melters (JHCM) processes to minimize the loss of volatile metals from glass. If such recycling is not possible, a small amount of these residuals (about 0.8 to 2.6 tons/day including spent reagents) may require treatment prior to disposal (Ref. 82). A cement-based chemical stabilization treatment process will be achieved by simple mixing of waste and reagents in drums. Bench and pilot scale testing will be required to validate and optimize this additional treatment step, if required.

The final filtration circuits of the off-gas treatment system consist of cleanable fabric or disposable deep-bed fiber pre-filters followed by primary and secondary HEPA filters. The pre-filters are expected to capture 99% of the particulates exiting the secondary aerosol scrubber. All of these solids (estimated to range from 8.4 to 15 lbs/day) will be recycled back into the melter for vitrification. Primary and secondary HEPA filters will collect 99.97% of the remaining particulates. These filters require up to seven years to become fully loaded, based on average scrubber efficiencies (Ref. 82). Conservative estimates are that these HEPA filters will be replaced annually to maintain a high margin of safety. Primary and secondary HEPA filter banks will hold an estimated total of 45 1,000-cfm filters per vitrification unit. This represents a total of 90 spent HEPA filters annually. Spent HEPA filters will also be recycled back into the melter for vitrification. If these HEPA filters are not recycled to the melter, they would amount to an estimated 1.44 tons or 13.3 cu yd/year.

If carbon is used in the radon control systems, it could also be cycled to the melter, thereby eliminating additional treatment of this waste material.

5.3.3.4.6 **Vitrified Product Strength**. The vitrified product must be strong enough to allow the disposal facility to be constructed and operate during the design life of the cell. This strength requirement is a function of the stability requirements discussed in Section 8.6. The strength of the fritted product has not been tested, but should be similar to that of silica sand. During pilot scale testing, a sufficient quantity of product should be made to allow the strength and consolidation characteristics to be determined by laboratory tests.

5.3.3.5 **Plant and Process Components**. This section briefly describes devices proposed for the major process circuits that will be integrated into design of the conceptual vitrification facility. Information is provided on the melter, additives, material preparation, radon emission control, waste storage and blending, melter feed, and product discharge circuits. Each major component of this facility is briefly described, along with alternatives considered and rationale for the component selected. A detailed evaluation of alternatives for these components is discussed in Section 6.3.3.3. All of the major components selected for various process circuits were chosen to meet the functional and performance criteria discussed in Section 5.3.3.2. It is important to note that all circuits in the vitrification facility will use state-of-the-art computer control systems, where applicable. These control systems will be linked to the control rooms, so that operators may communicate pertinent information about their systems to one another, thereby allowing real-time operational changes in the process, as necessary. A conceptual flow diagram of the vitrification facility is shown in Figure 5.3.3-1; the overall mass balance of this facility is given in Table 5.3.3-2. The preferred design for this facility is shown in Figures 5.3.3-2 (Raffinate Pretreatment), 5.3.3-3 (Soil/Clay Pretreatment), and 5.3.3-4 (Waste Blending, Storage, Feeding, Melting, and Product Discharge).

5.3.3.5.1 **Assumptions**. The following assumptions were used to develop this design:

Operations

Operations are assumed to proceed according to the following schedule:

Melter: 24 hours/day, 365 days/year.

Physical preparation circuits: two 8 hour shifts/day, 5 days/week, 52 weeks/year.

Approximately four years of operation (Ref. 71) (reducible to 2.9 years running at higher throughput-180 TPD).

90% mechanical availability.

15% over-design capacity.

Use of 50:50 solids ratio of raffinate sludge:soil/clay bottom material which melts at 1250°C.

Use of 100% soil/clay bottom material which melts at 1440°C.

Use of cyclonic fossil fuel heated ceramic melters (Ref. 84).

Use of natural gas for fuel (Ref. 84).

Melt modifiers such as soda ash, silica, or borate are unnecessary.

Material storage: a 7 day + supply of waste will be maintained at the vitrification facility.

Raffinate sludge has a dry bulk density of approximately 45 lb/ft^3.

Soils have a dry bulk density of approximately 90 lb/ft^3.

Vitrified product will have a bulk density of approximately 1.3 t/yd^3 (95 lb/ft^3).

Moisture Content of Wastes

Physical dewatering of the raffinate sludge is assumed to have been conducted prior to the delivery of the dewatered raffinate sludge at 80% solids to the vitrification pretreatment circuit. The facility is designed to process raffinate sludge, quarry soils, and clay bottom material with a moisture content of ≤20% on delivery. The conceptual process has

incorporated equipment to thermally remove water remaining in the wastes thereby yielding a constant moisture content feed.

Particle Size Limitations

The system will be designed to process -6 in. material. This feed material will be reduced to nominally minus 1 mm. prior to melting. Another size may be designated for the oversize (e.g., -2 in.). Size distribution information is necessary to determine the optimal oversize. For example, if significant amounts of soils slated for treatment are amenable to soil washing technology, this process may be considered as an appropriate additional treatment.

System Capacity

Based upon the above assumptions one calculates the following approximate capacities required for the melter and its ancillary devices and circuits to complete treatment within the constrained time frame:

160 ton/day of dry solids (Design).
140 ton/day of dry solids (Actual at 90% availability).
125 ton/day of dry solids (required throughput for a four year campaign).

Metering Accuracy Required

A metering accuracy for waste ±5%, by weight, is conservatively assumed to be required. Further bench-scale melt testing is required to determine actual accuracy necessary. This testing would evaluate the end member concentrations of important constituents in the feed, with respect to known variability in the melt, and variability induced by a number of metering accuracy windows. In general, the more accurate the metering of the feed, the more consistent the final product will be. The glass industry uses extremely well defined feed materials, and while a product such as window glass is not required, the use of the glass industry's operational approach would be conservative for our purposes.

5.3.3.5.2 **Proactive Problem Prevention.** The functional and performance criteria related data must be archived continually during operation. As expensive and time consuming as bench-, engineering-, and pilot- scale tests may be, they represent only a fraction

of the cost of rectifying a major product or operation failure once product failure is detected in the cell. This point emphasizes the need for not only preproduction testing, but also on going bench-scale testing conducted concurrently with production to evaluate operational changes resulting from changes in feed parameters. Data generated during the bench-, engineering-, pilot-, and production-scale tests will help to identify problems before they pose serious operational problems, and will provide information to regulatory agencies on the adequacy of the treatment process.

Potential costs and difficulties associated with a vitrification product failure indicate that conservative operating strategies should be employed. If such a failure were to occur, a relatively small volume of material could be retrieved and fed back through the melter with additional soil/clay or flux to rectify the previous problem with the waste form. The vitrification facility conceptual design proposes a sophisticated and relatively complex treatment system. However, this system will help ensure that a demonstrably correct glass mixture is formulated to reduce some of the uncertainty related to the minimal operational histories of vitrification treatment at other waste sites.

5.3.3.5.3 **Melter Circuits.** Fossil fuel-heated ceramic melters were selected as the optimal melter technology for the conceptual design because they exhibited the following advantages:

- Minimal residual waste- FFHCMs do not necessarily require the addition of melt modifying reagents, which increase the final volume and tonnage of the vitrified product and may exacerbate the formation of an immiscible sulfate phase, which can sequester constituents from the melt, resulting in the potential failure of the TCLP. PAT melters do not require addition of melt modifying reagents; JHCM melters do.

- Impact of system failure- cyclonic FFHCMs can readily be shut down and voided of melt, if required, without adversely affecting the melter itself. PAT melters can also be rapidly shut down, if required. JHCMs have a bathtub type melter required for operation, and therefore, are difficult to rapidly void and shut down.

- Additional treatment requirements- FFHCMs should not create an immiscible sulfate phase requiring additional treatment prior to disposal. PAT systems also

should not create an immiscible sulfate phase; JHCM systems would create this phase, as sodium based modifiers are required.

- Flexibility in accepting feed with variable chemistry- FFHCMs and PATs require less stringent control on feed chemistry, and therefore, can accept WSS waste with greater ease. JHCM systems require stringent control of both viscosity and electrical conductivity, which is done by adding reagents, and having well homogenized and characterized feeds.

- Cost - FFHCMs appear to have much lower capital and operating costs than either PAT or JHCM systems.

To meet functional and performance criteria, and to satisfy current site and schedule constraints, melter capacity must be in excess of 160 ton/day of waste on a dry weight basis. Current melter designs considered for this application exist in the 20 ton/day range. To minimize the scale-up required and to introduce the advantages of redundancy, a melter system having two independent melters was chosen. Vendor information suggests that melters of 75 ton/day and 100 ton/day will be available. The 75 ton/day melter is not large enough to meet the performance criteria, therefore, two 100 ton/day melters are included in this design. Melter circuits are further discussed in Section 6.3.3.3.1 A simple flow diagram of this circuit, as designed for one FFHCM (cyclonic), is shown in Figure 5.3.3-5.

5.3.3.5.4 **Additives and Waste Mixtures.** Sections 5.3.3.1 (General) and 5.3.3.3.1 (TCLP) introduce the idea of waste blending to produce a melt and vitrified product that meets the functional and performance requirements of the facility design. Waste blending is based on preliminary bench-scale vitrification testing of site wastes (Ref. 34, Ref. 33, and Ref. 80). Results indicate that WSS soils will melt at approximately 1400°C and form a vitrified product, but silica must be added to the raffinate sludge to produce a melt that has a desirable melting temperature and viscosity.

Silica could be added to the raffinate sludge in a number of ways to effect this change. Silica sand or waste glass could be added, increasing the total amount of vitrified product. The addition of silica-rich soil/clay, which requires treatment, to the raffinate sludge would also solve the silica deficiency. Therefore, it is advantageous to mix soil/clay and raffinate sludge to facilitate treatment of the raffinate sludge, instead of simply adding silica from clean sand or

waste glass. A wide range of raffinate sludge and soil mixtures were tested, and the results indicate that as little as 30% (dry weight) soil is needed to vitrify the raffinate sludge and produce an acceptable product that passes the TCLP test. It is unlikely that such a high raffinate sludge loading would be necessary, as soil and clay exist at approximately twice the weight (dry) of raffinate sludge at the site, and all of this material is slated for treatment.

It is also advantageous to mix the raffinate sludge and soil for energy consumption and processing concerns: the blended material melts at a lower temperature than soil alone and has a lower viscosity. The melting temperature and viscosity are functions of the actual blending ratio. A 50:50 blend melts at approximately 1250°C and has a viscosity of approximately 900 poise. At 1475°C the viscosity drops to approximately 200 poise. Those melting conditions are tolerated by available fossil fuel-fired ceramic melter (and plasma arc torch melter) equipment designs. While it is assumed that the raffinate sludge will be blended at a 50:50 ratio with soil or clay, and that soil or clay may have to be melted alone when raffinate sludge is unavailable, it is recognized that it may be beneficial to add some simple flux such as limestone to the soil/clay to reduce its melting temperature and viscosity for operational purposes, such as increasing melter life and decreasing melting temperature, and therefore, energy consumption. In all likelihood, one would want to use the raffinate sludge as sparingly as possible. It is likely, however, that soils or clay bottom material will exist at the end of the treatment campaign, without raffinate sludge available as a flux, and other simple fluxing materials such as crushed limestone will be needed.

Melter technologies, such as JHCM, which rely on electrical conductive heating to achieve melting of waste materials have more stringent feed chemistry requirements than FFHCM, which currently appears to be optimal for WSS and is the melter chosen for the conceptual design, or PAT melters.

Bench-scale testing of the WSS 50:50 and other raffinate sludge to soil/clay blends, with the required additives (typically Na_2O and B_2O_3 at a total additive amount of 10% (dry wt.) or greater) for the use of JHCM technology indicate that an undesirable immiscible sodium sulfate phase forms during melting (Ref. 33 and Ref. 80). The formation of this phase is undesirable for a number of reasons. Most importantly, this phase isn't inert, is readily soluble, and therefore not likely to pass any leach test criteria, including the TCLP. Many RCRA constituents of the waste are partitioned into the sulfate phase.

For the above reasons, it is advantageous to minimize the addition of additives and to limit them to non-sodium types and to blend the raffinate sludge or other flux-type wastes (site water treatment plant sludges) with the site soil-like wastes (clay bottom material, quarry soils, miscellaneous site soils). A 50:50 ratio of raffinate sludge to soil is anticipated to be adequate for this treatment recognizing that more bench-scale testing is required to further define the operational window for waste blending. Additives and waste mixtures are further discussed in Section 6.3.3.3.2.

5.3.3.5.5 Material Preparation Circuits. Pretreatment of the waste materials is required prior to their introduction to the melters. Two pretreatment options were considered: (1) minimal pretreatment with the introduction of the raffinate sludge as a slurry to the melter and introduction of the soil/clay to the melter after minimal sizing efforts, or (2) complete drying and sizing of all of the waste materials prior to introduction to the melter. Complete drying and sizing of the waste materials has been selected as the optimal pretreatment method for vitrification of site wastes. This option is advantageous mainly because it consistently provides a uniform feed to the melters. Material preparation circuits are further discussed in Section 6.3.3.3.3.

Two separate pretreatment circuits are needed to accomplish pretreatment of site wastes: one circuit dedicated to the pretreatment of the dewatered raffinate sludge, and the other dedicated to the pretreatment of soil and clay wastes. Both circuits accept waste materials at approximately $\geq 80\%$ solids, but could easily be modified to accept materials having lower solids content. All pretreatment operations are covered, as necessary, to minimize fugitive dust release.

The raffinate circuit accepts raffinate sludge from the dewatering facility at $\geq 80\%$ solids and ≤ 6 in. in the largest dimension, initially delumps/crushes the material to minus 0.5 in., and conveys it to a covered storage area which will hold approximately 750 tons of 80% solids material (600 tons dry solids equivalent). The minus 0.5 in. stored material is conveyed to an indirect dryer where it is dried to approximately 95% solids. Steam from this dryer is condensed and sent to the site water treatment plant for treatment. The raffinate sludge exiting the dryer is conveyed to a roller mill where it is further reduced in size to minus 1 mm (nominal) and increased in solids to approximately 99%. The moisture evaporated during size reduction is also condensed and sent to the site water treatment plant. The raffinate sludge exits the mill building and is conveyed to a 350 ton storage silo where it awaits transfer to the feed

blending circuit. It is anticipated that other wastes such as the site water treatment plant sludge and crushed lime, if used, would also be treated in this pretreatment circuit as required. Figure 5.3.3-6 is a flow diagram of the raffinate sludge pretreatment circuit.

The soil and clay pretreatment circuit is operated differently depending upon whether soil or clay is to be treated, as the properties of the two materials are believed to be significantly different: soil is granular and clay is very cohesive and difficult to handle. The soil circuit would accept soil, pass it over a 6 in. grizzly and reject the + 6 in. portion which would be periodically removed and placed directly into the disposal facility; the potential also exists for minimal treatment of this oversize prior to placement. The minus 6 in.undersize is conveyed under a magnet to remove tramp metal and debris and then into an impact crusher where its particle size will be reduced to minus 0.5 in., and conveyed to a 1500 ton (1200 ton dry solids equivalent) covered storage pile. This material is then conveyed to an indirect dryer where its solids content is increased to approximately 95%. The moisture removed during drying is condensed and sent to the site water treatment plant for treatment. The dried soil is conveyed to a roller mill where it is further reduced in size to minus 1 mm (nominal) and increased in solids to approximately 99%. The moisture evaporated during size reduction is also condensed and sent to the site water treatment plant. The soil exits the mill building and is conveyed to one of two 350 ton storage silos where it awaits transfer to the feed blending circuit. It is anticipated that the quarry soils and the miscellaneous site soils would be treated in this pretreatment circuit, as required.

Clay bottom material requires slightly different handling than soils. The above circuits are used for pretreatment of the clay, but a modification is required at the beginning of the circuits. Instead of feeding the clay directly into the grizzly and past the magnet, the clay is introduced to a shredder where its size is reduced to minus 6 in. The shredded clay is then conveyed to an indirect dryer where its solids content is increased to approximately 90%. Moisture removed in this drying step is also condensed and sent to the site water treatment plant. This partially dried clay is now easier to handle and is sent to the impact crusher mentioned in the soil pretreatment circuit above. The clay now follows the same circuit as the soil. The only difference in the operation of the soils circuit when using clay, is that the demand on the indirect dryer (second for clay) is less, due to the clay solids content at introduction is 90% compared to the 80% solids content of the soil. The dryer selected is robust enough to handle this variability. It is planned to only treat soil or clay at one time, therefore operations do not

require handling of both materials simultaneously. Figure 5.3.3-7 is a flow diagram of the soil/clay pretreatment circuit.

5.3.3.5.6 **Radon Emissions Control.** The relationship of radon emissions to vitrification treatment has not been thoroughly evaluated; however, it is known that radon removal, if necessary, must take place to the extent possible at a location other than in the off-gas treatment circuit. It is anticipated that radon removal would require multiple efforts at a number of process points. This removal is likely to be initiated as early in the processing of wastes during the dredging of the raffinate sludge and will continue throughout removal efforts during material pretreatment and storage operations. More data are required to adequately assess the need, optimal placement, and design of radon removal equipment. Radon emissions from the solids during melting must also be evaluated during further bench and pilot testing.

5.3.3.5.7 **Waste Storage and Mixing Circuits.** These circuits are designed to accept the pretreated waste materials, blend them to prepare the feed for the melters, and store this feed for transfer to the melters. Mechanical and static systems are available for this task; a static mixer system has been chosen. Static systems are advantageous because of their simplicity and general lack of moving parts that require maintenance. Waste storage and mixing circuits are discussed in more detail in Section 6.3.3.3.5. Two separate and parallel storage systems are required, one for each melter. This duplication adds to the robustness of the overall facility and should minimize overall facility downtime.

Waste materials are pneumatically transferred from the storage silos described in the material pretreatment circuits to the storage bins near the melters. These storage bins are sized for 45 tons of prepared waste each or roughly the amount required at a maximum necessary to feed one melter at its maximum capacity for 1.5 8-hour shifts. Two of these bins are required for each melter; one bin that will be actively feeding the melter and another bin that will be in the process of being filled. Each of the bins will be on load cells to allow accurate determination of materials transferred to the bin and vitrified. Blending will be conducted by a static mixer located between the raffinate sludge storage silo and the soil/clay storage silos. The static mixer is fitted with flow controllers for both raffinate sludge and soil/clay to maintain the required ratio of waste materials. After the waste materials are pneumatically transferred from the storage silos through the static mixer to the bin, the blended feed material will be fed to the melters. Figure 5.3.3-8 is a simple flow diagram of this circuit.

5.3.3.5.8 **Melter Feed Circuits.** These circuits are designed to transfer the pretreated and blended waste materials from the previously described storage bins to the melter. Alternatives include pneumatic and mechanical transfer systems. Pneumatic feed systems have been selected for this design. Both systems could be adapted to the melter selected; pneumatic systems have a few advantages over mechanical systems. Pneumatic systems use positive air pressure to transfer feed to the melter. FFHCMs have a back pressure that must be overcome for this feeding to occur, therefore pneumatic systems can be easily adjusted to overcome a variable back pressure that may come from the operation of melters at variable throughputs. Mechanical systems, using equipment such as screw feeders (conveyors) with pressure fittings, could be used; but would require high maintenance and periodic replacement of many of the moving parts; pneumatic systems have lower maintenance requirements, and therefore, less anticipated down time.

The pneumatic feed systems, one for each melter, include piping and connections to each of the storage bins for each melter. Connections at the melter include one-way check valves to allow flow from the bins to the melter, but not back flow from the melter into the feed system. Connections at each melter storage bin allow the melter to be fed from either of the bins. Each bin is fitted with vibrational devices to prohibit bridging of feed. If one of the bins goes out of service for a period of time, the melter could be almost continually fed from the other bin with downtime occurring only during that bin's filling cycle, which is estimated to be less than 0.5 hour. This flexibility lends robustness to the design. Figure 5.3.3-8 includes a flow diagram of this circuit.

5.3.3.5.9 **Product Discharge Circuit.** The alternatives considered for product discharge circuits included water quenching (fritting), shaping, and forming in containers. The selected alternative was water quenching. The generation of a fritted product has many advantages over other alternatives. The product produced is not dangerous to handle, from a thermal hazard standpoint, and can be easily handled and placed in the disposal facility with commonly available earthworking equipment already in use at the site. This alternative is physically safer to handle and less energy intensive than alternatives that require annealing to stabilize the glass to prevent explosions caused by unequalized stresses within the glass. The quality of the vitrified product does not require containment above simple burial, because the constituents of concern are either effectively destroyed or immobilized within the glass matrix, and the vitrified product will be placed within the disposal cell as an additional and redundant safety measure.

The discharge circuit is relatively simple. The molten glass from both melters will be directed into a water cooled chute that leads to a single water quench tank where the product will be frozen into a frit. The frit will be lifted from the tank via a screw conveyor, which will dewater the frit as it transfers it to the elevated storage bin. The frit will be stored in the bin until it is transferred, via an automated transfer system, to trucks for delivery to the disposal cell. An automatic sampler is installed in this circuit to collect QC samples of the vitrified product for testing and archiving for documentation. A cooling system for the water in the quench tank is included to minimize the generation of steam and loss of water; the quench water will be recycled until the solids content increases, due to the evaporation of water, to the point it might interfere with the pumping and cooling system. Figure 5.3.3-9 is a flow diagram of the product discharge.

5.3.3.5.10 **Off-Gas Treatment Circuits.** The flow exiting the vitrification melters still contains products of incomplete combustion, chlorine, fluorine, heavy metals, NO_x, SO_x, and particulate matter. These contaminants must be controlled before the off-gas is released to the atmosphere. The following off-gas technologies (listed in order of final ranking) were evaluated (Ref. 83):

- Quench scrubber/spray dryer/dry venturi/baghouse
- Low pressure drop venturi/tandem nozzle scrubber
- Low pressure drop venturi/collision scrubber
- Low pressure drop venturi/ionizing wet scrubber
- Spray dryer/baghouse/high pressure drop venturi
- Low pressure drop venturi/wet electrostatic precipitator/low pressure drop venturi/ionizing wet scrubber
- Low pressure drop venturi/packed bed scrubber
- Air or spray cooling/dry scrubber/cyclone/electrostatic precipitator/fabric filter

- Spray dryer/baghouse/low pressure drop venturi
- Low pressure drop venturi/centrifugal scrubber/wet electrostatic precipitator
- Submerged bed/packed tower
- Spray dryer/electrostatic precipitator
- Spray dryer/fabric filter

After evaluating the expected performance of each of these systems using MVE techniques for various criteria, the quench scrubber/spray dryer/dry venturi/baghouse system was selected as the best system to treat the off-gas from the melter. This system was judged slightly better than the others in the areas of residual waste reduction and acid gas control. Any of the top five systems above could easily treat the off-gas stream, and further analysis, including engineering and pilot studies, are needed to determine which one of these systems would be incremental superior to the others. Additionally, it appears that any of the top five systems would meet the emission criteria listed in Section 5.3.3.4.3. The team also assumed NO_x control is necessary, and radon control is achieved elsewhere in the treatment process.

Detailed descriptions of the treatment systems and the criteria used to rank the technologies are given in Section 6.3.3.3.8. A spreadsheet was used to determine the mass balance for the selected off-gas system. Total feed rates to the melters of 120 ton/day and 180 ton/day were used. Expected control efficiencies for each stage of the selected off-gas technology were used to simulate actual operating conditions. The concentration of the constituents in the melter feed was calculated by assuming an equal mix of raffinate pit soils and quarry soils. The weighted average constituent concentrations of the four raffinate pits was used with average quarry soil concentrations. The conceptual process flow diagram for the selected off-gas technology is presented in Figure 5.3.3-10. Calculated process flow rates at 10 points of the off-gas system are given in Table 5.3.3-3. Table 5.3.3-4 presents the percentage of material captured in the vitrified product, percentage of waste needing further treatment, and the emission rate for predominate contaminates for both feed rate scenarios.

5.3.3.6 **Plant Location**. The location of the proposed vitrification facility is east of the raffinate pits as shown in Figure 5.3.3-11. This location is advantageous due to it's

proximity to the dewatering facility, raffinate pits, TSA, site water treatment plant, and disposal cell. Other areas that might be used are currently scheduled to contain other activities, or are removed in proximity from the waste sources and disposal location.

5.3.3.7 **Specifications.** The following table provides a list of specifications anticipated to be required for Title II design efforts.

Description of Specification
MECHANICAL SPECIFICATIONS
Inlet hoppers; 5, 10, and 15 cu yd capacity; and 10 ft^3 capacity, conical bottom with top cover.
Disintegrator, capacity 18 tph.
Chain conveyor, capacity 18 tph, horizontal L = 10 ft., vertical 17 ft., upper horizontal 4 ft.
Indirect heated holo-flite dryer, capacity 18 tph, inlet particles -6 in., 80% solids; discharge 90% solids, hydraulically driven.
Drag conveyors, capacity 18 tph, L = 50 ft, H = 12 ft (discharge) structural steel (equipment support and platforms).
Filter, air.
Filter, water.
Oil heater, inlet T = 502°F, discharge T = 600°F (ΔT 100°) with burner - natural gas, and air fan, heat capacity 3,600,500 btu/hour.
Oil circulation tank, capacity 500 gal, including valves and insulation.
Oil circulation pump, Q = 231 gpm, TDH = 75 psi, pumping temperature 502°F.
Scalping grizzly, capacity 18 tph, mat. 80% solids min, including undersized bottom chute.
Oversized bin, 25 cu yd capacity.
Covered belt conveyors, capacity 18 tph, inclined 15°, with support structure steel and take-up system L = 80 ft and 120 ft; and capacity 18 tph, inclined 15° with support structure steel and take-up system L = 85 ft; and capacity 9 tph, inclined 15°, with support structure steel and take-up system L = 85 ft and 125 ft.
Tramp iron magnet, including monorail.
Impact mills; capacity 18 tons/hour., inlet particle size -6 in., discharge -1/2 in.; and capacity 9 tph inlet particles -6 in., discharge -1/2 in.
Vibrating feeders (under storage piles), capacity 9 tph and 18 tph.
Indirect heated holo-flite dryer, capacity 9 tph, inlet particles -1/2 in. 80% solids, discharge 95% solids.
Roller mills, capacity 7.5 tph and 15 tph, inlet: 95% solids, particle size - 1/2 in., discharge: -1 mm, 99.5% solids.
Indirect heated dryer holo-flite type, capacity 9 tph inlet particles -6 in., 80% solids, discharge 95% solids.
Condenser, inlet vapor at 210°F, 1400 lbs/hour, cooling water temperature 70°F.
Deareation tank, 1000 gal capacity with cooler and valves.
Cooling towers (estimated Q = 10, 15, and 20 gpm, ΔT 40°).

Description of Specification
Water pumps; discharge, 3 gpm, TDH = 30 psi; and circulation, 3, 10, and 30 gpm, TDH = 50 psi.
Water filters, Q = 10 & 15 gpm, cartridge type. Raffinate sludge storage silos, raffinate sludge (1) and soil/clay (2), material size -1 mm, bin capacity 300 tons, bolted type, bin including bin filter - HEPA type, estimated bin diameter 16 ft & H = 40 ft active. Static mixer. Melter feed bins, including bin filter (HEPA type) bin capacity 45 tons. CRV combustors, capacity 100 tph, fossil fuel-heated vitrification unit heated by N.G., water cooled combustor jacket; inlet particle size -1 mm, >99.5% solids. Combustor consists of CRV combustor, cyclone melter, separator reservoir and recuperator. Frit screw conveyor - included with 1/3 of length without shell submerged in glass particles L = 15 ft. Frit loading bin, 15 ton capacity of glass, stainless steel. Cooling reservoir.
Air compressor with air tank and ohem. dryer capacity 50 ACFM at 175 psig. Monorail, 5 ton capacity.
Front end loader, 5 cu yd. Airlock, 7 tph capacity. Pneumatic systems for raffinate sludge and soil/clay transfers. Fuel feed system.
Total Mechanical Specifications = 37
Civil/Structural Specifications
Site preparation and grading. Excavating and backfilling from foundations and structures. Aggregate base course. Concrete reinforcement. Cast-place-concrete. Unit masonry. Structural steel fabrication. Structural steel erection. Steel joists. Steel roof deck. Metal fabrications.

Description of Specification
Total Civil/Structural Specifications = 11
Electrical and Instrumentation Specifications
Electrical installation and materials.
Electrical motors and accessories.
Secondary unit substations.
Low-voltage motor control centers.
Panelboards and schedules.
Lighting fixtures and schedule.
Electrical heat tracing.
Fire alarm system.
CCTV system.
Communication system.
Programmable logic controller (PLC).
Main control panel and accessories.
Instrumentation installation and materials.
Instrumentation index list.
Pressure instruments and transmitters.
Flow instruments and transmitters.
Level instruments and transmitters.
Density instruments and transmitters.
Indicators, controllers and recorders.
Conveyor instrumentation.
Instrumentation mounting details.
Total number of Electrical and Instrumentation Specifications = 21

5.3.3.8 Applicable Codes and Standards. The codes and standards currently anticipated to be applicable to the final design are those listed in this section. These codes and standards may change due to changes in pertinent law or changes in the design during Title II efforts.

- ACI - American Concrete Institute
- AISC - American Institute of Steel Construction
- AISI - American Iron and Steel Institute
- ANSI - American National Standards Institute
- ANSI/NFPA 70 - National Electrical Code (NEC)
- ASCE - American Society of Civil Engineers
- ASTM - American Society for Testing and Materials
- AWS - American Welding Society
- CRSI - Concrete Reinforcing Steel Institute
- IEEE - The Institute of Electrical and Electronics Engineers, Inc.
- ICEA - Insulated Cable Engineers Association
- NEMA - National Electrical Manufacturers Association
- NFPA - National Fire Protection Association
- NFPA 70E - Electrical Safety Requirements for Employee Workplaces
- OSHA - Occupational Safety and Health Administration
- RCSC - Research Council on Structural Connections
- SDI - Steel Deck Institute
- SJI - Steel Joist Institute
- SSPC - Steel Structures Painting Council
- UL - Underwriters' Laboratories, Inc.

5.3.4 Size Reduction

5.3.4.1 General. The objective of size reduction is to size the building debris, rubble, equipment and other material during building dismantlement and demolition for segregation, hauling, and placement at the MSA, TSA, ACM storage area, Building 434, or Ash Pond area for eventual placement in the on-site disposal cell. Technical specifications within the three building demolition subcontracts (Work Packages 255, 256, and 257) define the process of removal, sorting, size reduction, and transportation of dismantled debris to one of the temporary storage facilities. The specified methods of size reduction in these subcontracts include almost all of size reduction requirements for placement of the materials in the on-site disposal cell. Future subcontracts that will require sizing of materials are the building foundations removal, Imhoff tank removal, and general wood consolidation and chipping subcontracts.

5.3.4.2 **Performance and Functional Criteria.** Size reduction of building demolition debris shall be consistent with that performed for the removal, handling, sorting, and size reduction of debris for transportation and storage at one of the temporary storage facilities. Size reduction shall also be consistent with the needs for transportation, placement and disposal within the on-site disposal facility. Alternatively, size reduction and decontamination for recycling may be required at the MSA.

5.3.4.3 **Regulatory Concerns.** There are no specific regulations, either Federal or State that require size reduction of waste material. However, health and safety procedures will be followed during size reduction activities in accordance with the Weldon Spring Health and Safety Plan (HASP) and any task-specific HASPs that may be developed in the work packages for the chemical plant dismantlement and demolition contracts.

Health and safety rules will be followed at all times. Specific activities requiring strict adherence with the HASPs include:

- Safety of workers during the removal, handling, and storage of contaminated materials. Safety factors that will be considered include handling of contaminated waste; handling of materials of various shapes such as rebar, pipes, concrete; safety issues related to the operation of equipment; and other topics that will be identified and detailed in the HASPs.

- Personnel safety during the transport of materials on site roads.

5.3.4.4 **Debris Characterization.** Interim response actions have been undertaken at the Weldon Spring site to remove, sort, size reduce, haul, and place dismantled building material in one of the temporary storage facilities. The specifications for Dismantlement and Demolition Packages 1, 2 and 3, are found in Section 02055 of the specifications which categorize the debris. Table 5.3.4-1 lists the major categories of demolition debris and each of their components. For convenience and consistency, this same waste division is considered adequate for all future demolition work that may be required.

5.3.4.5 **Identification of Alternatives.** An MVE session was conducted to define and evaluate the alternatives for size reduction of different types of construction debris and to

optimize material sizing for disposal in the cell. Listed below are the alternatives considered in the MVE session:

- Dismantling material for cell disposal.
- Dismantling material for recycling (restricted release).
- Melting material.
- Compacting material.
- Shredding material.
- Cryofracturing material.

The following criteria were developed to evaluate each of these alternatives: (1) worker health and safety, (2) facilitating placement in cell, (3) cell volume reduction, (4) minimizing labor intensity, (5) relative unit cost, and (6) facilitating cell performance. Facilitating the disposal cell performance is considered the most important criteria because inappropriate size reduction could cause voids and subsidence of the waste and cover of the completed cell, thereby shortening cell life or compromising performance. Worker health and safety is considered the next most important criteria, both from an occupational as well as a radioactive exposure standpoint and is considered only slightly less important than accomplishing the mission of the task. Reducing the volume of the cell, minimizing the amount or intensity of the labor effort, and the relative cost of reducing the size of the waste were all considered equal and much less important than the first two criteria. Facilitating placement in the cell was ranked last because, given the size of the materials being considered and the methods of disposal being used, any of the materials could be placed in the cell and properly disposed of without further size reduction. By identifying and weighing the desired criteria for each individual function of each alternative, a preferred alternative was chosen. The dismantling of material for cell disposal alternative was chosen because it will maximize handling size and minimize the void space in the disposal facility.

The results of the MVE session are shown on Table 5.3.4-2. Following this initial determination, each of the major groups were individually studied for additional size reduction needs. Only those having viable alternatives are detailed in MVE Table 5.3.4-3 size reduction results of modified value engineering. All other groups do not require size reduction other than what is designated in the demolition specifications in Work Package 255, 256 and 257.

Little, if any, further size reduction beyond demolition subcontract requirements is necessary to facilitate debris placement in the disposal facility. The operations involving size reduction are discussed in Section 6.9.4.

5.3.4.6 Technical Uncertainties. Using the observational approach, MVE Table 5.3.4-4 presents the expected condition for all of the debris grouping, the potential deviation, probability of occurrence and effect on operations. No major problems were identified that could not be dealt with in day-to-day operation. Conventional size reduction equipment such as cutting torches, jaw crushers, and hoerams would be used.

5.3.4.7 Specifications. Specifications for each material group, removal process, handling, sorting, size reduction requirements, and storage areas are defined in Work Packages 255, 256, and 257. In addition, the specifications for removing building slabs, foundations, underground utilities, and contaminated debris and soil will be developed in the Title II Design.

Other related areas include the health and safety requirements for all building dismantling work packages, Section 01712 (PCB Decontamination and surface Cleaning Procedures for Concrete, Equipment, and Structures) and Section 02063 (Demolition of Asbestos-Containing Material and Fiberglass Insulation).

5.3.5 Dewatering

5.3.5.1 General. Dewatering the raffinate pit sludge prior to treatment is desirable for both the treatment processes being evaluated (CSS and VIT). The objective of this task is to develop a conceptual dewatering process design which meets the feed parameters of both the CSS and VIT plant designs as described in Sections 5.3.2 and 5.3.3, respectively.

The CSS facility will produce two types of treated product: grout like and soils like. The feed materials for both CSS product types must include raffinate sludge that contains approximately 27% solids and 73% water. However, different feed rates are necessary. The feed rate required to produce the grout-like product is 57 tph on an in place weight basis, whereas the feed rate for the soil like product is 36 tph. The tentative requirements for the VIT process, on the other hand, are 5 tph to 10 tph of feed containing approximately 80% solids and 20% water.

Because the moisture content requirements for the CSS and VIT processes are different, the dewatering requirements are also different. The dewatering designs and operations presented in this section address three possible scenarios to accommodate the different dewatering demands:

- Supplying a pretreated material to the CSS plant without dewatering.
- Supplying a pretreated and dewatered material to the CSS plant.
- Supplying a pretreated and dewatered material to the VIT plant.

These three scenarios are shown in Figure 5.3.5-1. Supplying a non-dewatered material for CSS may be a viable alternative and, in this task, is considered the first scenario. Non-dewatered refers to material that has not been processed through a mechanical dewatering device such as a filter press. This material would pass through a pretreatment process consisting of classifying, agitated storage, flocculant mixing, and thickening, as shown in Figure 5.3.5-1. Field tests have determined that a grout-like material can be produced from the raffinate sludge as it leaves the pretreatment stage. If this material meets the compaction specifications, then the raffinate sludge will not require dewatering prior to CSS treatment. Nevertheless, dewatering the sludge will be advantageous because an excessive water content weakens the CSS product, consumes a greater amount of reagents, and increases the volume of material requiring treatment.

5.3.5.2 **Functional and Performance Criteria.** The general functional requirement of the dewatering process is to prepare the raffinate pits sludge for either CSS or VIT treatment. The pretreatment process consists of seven major functions: (1) removing metal (iron and steel) objects from the sludge, (2) classifying (screening) the slurry to separate the fine and large particles, (3) mixing the slurry solids in an agitated storage device, (4) adding flocculant to the sludge to induce binding/cohesion among the solid particles and speed setting, (5) mixing the sludge in a blender/mixer, (6) thickening the sludge in a thickener through the processes of time (allowing the flocculant to function) and agitation, and (7) dewatering (depending on the scenario selected for remediation). The dewatering process and the accompanying details are illustrated in Figure 5.3.5-1.

The performance criteria for the dewatering process is to meet the feed parameters for a CSS or VIT treatment process. The CSS plant feed requirements are based on the two product options:

1. To produce a grout-like product at the rate of 80 tph, the dewatering plant will treat 102.6 tph of slurry containing 15% solids, 85% water yielding 57 tph of dewatered sludge with 27% solids, 73% water.

2. To produce a soil-like product at the rate of 80 tph, the dewatering plant will treat 92 tph of slurry containing 15% solids, 85% water yielding 36.4 tph of dewatered sludge with 27% solids, 73% water.

The sludge feed to the VIT plant will consist of 5 tph to 10 tph of sludge containing 80% solids and 20% water. In addition, these feed materials will not contain any oversized particles or metal objects.

5.3.5.3 **Regulatory Concerns.** The dewatering facility will operate to meet the needs and production schedule of the CSS or VIT plants. The dewatering facility will operate in compliance with all Federal, State, and local regulatory requirements and DOE orders. After the dewatering operations cease, the facility will be dismantled and, depending on the degree and type of radioactive contamination, will either be disposed of in the disposal cell or taken off site for further use.

One of the major concerns during the operation of the facility deals with the emission of radon. Radon will be released during various stages of the dewatering process; therefore, radon control and detection/monitoring devices will be installed to minimize these emissions. In addition, ambient air around the dewatering facility will be monitored for potential air contaminants and to alert operators of potential radon control system failures. Ongoing continuous air sampling will be continued at the site perimeter to evaluate compliance with the National Emission Standards for Radionuclide Emissions from Department of Energy Facilities as well as other State and Federal ambient air standards. The perimeter air monitoring stations will detect changes in air quality caused by dewatering and other remediation activities.

The water released during the dewatering operations will be returned to the raffinate pits or conveyed to the site water treatment plant. No other releases of water are planned. Because the facility will not discharge water off-site, ambient water quality will not be impacted and no discharge permits should be required. Any additional regulations that relate to the dewatering process will be detailed during final design.

5.3.5.4 **Raffinate Sludge Characterization.** The raffinate pit sludge is composed of very fine-grained silica and silicate minerals and other insolubles associated with the ore feeds, along with metal hydroxides and other precipitates formed during pH neutralization. The fine-grained sludge has a relatively high moisture content, averaging 73% water by total weight.

The quantities of sludge in the four raffinate pits are given in Section 5.3.1.1, Waste Characterization, and include the density, wet tons, and the estimated dry tons of raffinate sludge to be treated. The sludge will be removed by a barge-mounted cutter-head dredge. The dredging process will increase the water content of the sludge, and the dewatering facility has been conceptually designed to handle sludge with a high water content. Details of the dredging operation are discussed in Section 5.1.2, Waste Removal.

Chemical contaminants include inorganic ions such as nitrate, sulfate, phosphate, fluoride, and chloride; numerous metals; and metalloids such as arsenic, lead, mercury, barium, and selenium. Radioactive contaminants include the radionuclides of the uranium and thorium decay chains. The sludges were analyzed by Waste Technologies Group (WTG) and Chen-Northern Inc. (C-NI). The x-ray analysis of the sludge and additional information on the raffinate pit sludge is given the WSS waste characterization described in Section 5.3.1.

5.3.5.5 **Dewatering Design Components.** Conceptual design of an operable dewatering facility involved the selection of the following process components and topics:

Pretreatment Components

- Metal separator (optional)
- Classifier
- Agitated storage device
- Reagents/flocculants
- Blender/mixer
- Thickener

Dewatering Components

- Dewatering method
- Equipment for a CSS plant feed
- Equipment for a VIT plant feed

Other Components

- Radon emission control and detection/monitoring
- Product discharge
- Location of the dewatering facility

The preferred alternatives for both individual and combinations of components were selected based on the identification and evaluation of these alternatives in MVE sessions. Feasible assumptions or parameter and data estimates were incorporated where specific information was not available; therefore, as new data is generated, the conceptual design presented herein may be modified during Title II design.

5.3.5.5.1 Metal Separator (Optional). A metal separator is needed in the front end of this system to prevent metal objects from damaging the classifier screening materials. This device may be installed at the dredge head before the sludge is passed through the dewatering process. A magnetic separator is needed to remove the iron and steel debris that may be encountered in the raffinate pits sludge. Removing this debris will minimize damage to and plugging of dewatering equipment. There are no other practical metal-removing devices available, so no alternatives were considered. The magnetic separator will be attached to the pipe forming the discharge end of the dredge. All the materials collected by the metals separator will be transferred to the TSA for storage and subsequent processing and/or disposal.

5.3.5.5.2 Classifier (Optional). A classifier may be installed at the dredge to separate and remove oversized materials such as trash and debris from the sludge. As an alternative the classifier equipment can be an integral part of the dewatering plant. The large particles sorted by the classifier will be stored in a pile and subsequently transported to the TSA or the disposal cell. The fines will proceed through the remaining dewatering process.

The types of classifiers evaluated were those that best apply to the particular raffinate sludges and that are widely used in the mineral processing industry.

- Vibrating screen
- Stationary wet sizing screen
- Rotating screen or trommel

These alternatives were evaluated in an MVE session (Table 5.3.5-1). The rotating screen or trommel is the preferred alternative because of superior safety features, reliability, known technology, ability to handle sludge, capacity, ease of operation, ease of controlling radon emissions, efficiency, energy consumption, maintenance requirements, and cost.

The rotating screen classifier consists of a horizontal, metal, cylindrical screen that slowly rotates and separates the different sized solids. Particles smaller than 1 in. that pass through the screen are pumped into the storage tank; larger particles would be dumped in a temporary pile adjacent to the classifier and subsequently transported to the TSA or to the disposal cell. The rotating screen classifier can be cleaned easily, provides material enclosure, and thus some protection from human contact and accidental spills. This device also can screen large volumes of material. The feed rate for the slurry to be dewatered for the CSS grout-like product, is 102.6 tph; 92 tph for the soil-like product; and 40 tph to 50 tph for vitrification. The raffinate pit sludge is estimated to contain not more than 25 % solids and would be suitable for screening in this device. Rotating screens are widely used as a sludge classifier and are a reliable device; the maintenance requirements are moderate.

The trommel classifier is preferred over the vibrating screen (shaker type) because of its ability to handle heavy, wet, and dense slurries. Because of the rotating and tumbling action of the trommel, it has less tendency to plug and, therefore, minimizes shut-down requirements for cleaning.

5.3.5.5.3 **Storage Device (Optional).** A device may be required to store the raffinate sludge and to act as a buffer to control surges and feed variations caused by the dredging operation. Such a structure/device may have to meet RCRA requirements such as secondary containment. The raffinate pit sludge is stored in an agitated storage tank to minimize particle settling. It may not be practical to feed the raffinate sludge directly to the dewatering plant because of the pump surging action and the varying density of the raffinate sludge. The

free water on top of the solids is decanted and piped into the raffinate pit, while the solids are pumped to the thickener. The storage devices considered feasible include:

- Agitated-storage tanks
- Storage basins

These alternatives were evaluated in an MVE session (Table 5.3.5-2). The preferred alternative is a carbon steel agitated-storage tank. Even though the fabrication and erection costs for the agitated storage tank are higher than for an earthen (plastic-lined) basin, the advantages of an agitated storage tank regarding relocation, ease in controlling or minimizing radon emissions, ease in winterizing, and personnel safety outweigh the advantages of a storage basin.

Another alternative is using an existing groundwater storage tank at the site that is capable of storing approximately 700,000 gal. The two options to consider are (1) that this tank can be floated and moved to the dewatering plant area for storage, and (2) that the tank can be cut and dismantled. These metal sheets can be fabricated into two settler tanks. Both of these options are labor and capital intensive. During the dredging operation, it is estimated that the slurry will contain 5 % to 25 % solids. The settling process in the tank allows the solid particles in the slurry to settle to the bottom, generating a feed with a more uniform water content to the remainder of the dewatering process. The excess water above the solids is then pumped back into the raffinate pit (refer to Figure 5.3.5-1).

It is possible that this could be the first step in reducing the amount of water in the sludge. The amount of water removed at this stage is difficult to predict. The effectiveness of this initial dewatering process can only be determined during actual processing or pilot testing. The sludge at the bottom of the storage tank may then be pumped to the blender/mixer where a flocculant is added. The conceptual CSS plant design will provide storage facilities for the dewatered feed materials.

5.3.5.5.4 Reagents. Flocculants cause the solid particles within the sludge to bind or adhere to each other, thereby allowing the larger, heavier particles to settle rapidly. Flocculants are forms of high-molecular-weight polyelectrolytes (organic polymers) that are available in anionic, cationic, and nonionic forms and are widely used to thicken and densify sludge. The flocculant is metered into each cone section of the auger/mixer. Figure 5.3.5-2 demonstrates the conceptual process design with the flocculant being added to the sludge prior

to mixing. During recent bench-scale tests, flocculants were added to the raffinate pit sludge. Test results indicate that the flocculants improve the settling characteristics of the solids. Without flocculant, the thickener would have to be very large, and the time required for the solids to settle and thicken would not be efficient or practical. In addition, the handling properties of unflocculated sludge would not be amenable to subsequent processing. The types of flocculants evaluated include:

- Organic polymers
- Coagulants (inorganic salts)

These alternatives were evaluated in an MVE session (Table 5.3.5-3). The preferred alternative is the organic polymer. The major advantages of these flocculants are that they are not pH sensitive, and that inorganic constituents in the sludge will not interfere with the binding effect as coagulants would. The organic polymers are also easier to apply than the coagulants, because the latter type requires the mixing of various ingredients. The cost of organic polymers, however, is higher than the inorganic salts used for coagulation. Both of these materials are readily available.

Coagulants may be used to remove suspended solids from wastewaters. Chemical coagulation is the process whereby the destabilized suspended raffinate sludge solids are allowed to come into contact with one another, agglomerate, and settle out. Lime, ferric chloride and alum, alone or in combination, are widely used as coagulants. These highly charged hydrolyzed metal ions produced by salts in solution reduce the repulsive forces between the solids particles by compressing the diffuse double layer surrounding individual particles. With the forces of repulsion suppressed, gentle mixing results in particle contact, and the forces of attraction cause particles to stick to each other, producing progressive agglomeration. The salts of many of these coagulants are corrosive and require costly storage devices.

A series of bench-scale studies was designed to determine the settling and flocculating characteristics of the raffinate sludges. The flocculants selected for screening were obtained from different suppliers. In each case, a manufacturer was consulted, and the types of flocculant thought to work best for a hypothetical raffinate sludge were used. Gypsum and anhydride-dominated sludges were used as the hypothetical reference that best defined the physical characteristics of the Weldon Spring raffinate sludge solids. The flocculants were tested on raffinate sludge samples, and a summary of the test results is presented in Table 5.3.5-4. The

best performing flocculant screened from the initial on-site tests was a high molecular weight anionic polyacrylamide. Test results are further described in an Inner-Office Communication (Enger, February 12, 1993, Appendix A).

Additional on-site testing using larger quantities of sludge slurries containing approximately 15% solids of composited Pits 1, 2, and 3 showed that an average flocculant concentration in the slurry of approximately 225 ppm is needed for adequate flocculation. If the flocculant needs exceed 500 ppm, the chemical costs may be excessive.

5.3.5.5.5 **Blender/Mixer (Optional).** The blender/mixer is a device that mixes flocculant and sludge. After a series of flocculating and settling tests on the WSS raffinate sludges, it was concluded that this material needs to be mixed with flocculants. Results from recent bench-scale studies (Enger, February 12, 1993, Appendix A), indicate that these slurries need to be flocculated, and that the flocculant has to be uniformly mixed throughout the system to make contact with the solids. This mixing may not require a mixing device; the final decision regarding the need for a mixer will be made during Title II design. For conceptual design purposes, however, a mixer has been included in the process. The following blenders/mixers commonly used to handle dense slurries were evaluated:

- Rotary agitated mixer/blender (cone-shaped vessel with rotating auger)
- Auger/mixer (tank with an agitator)

These alternatives were evaluated in an MVE session (refer to Table 5.3.5-5). The auger/mixer was selected as the preferred alternative. The auger/mixer consists of two down-slope cone units with a rotating auger/mixer on the inside. The flocculant is added at the same time the slurry is fed into the unit. The circular motion of the agitators mixes and blends the slurry with the flocculant (Figure 5.3.5-1).

The auger/mixer is considered superior to the rotary agitated mixer/blender (RAMB) due to its ability to mix and feed a denser slurry to the thickener. The RAMB unit depends on a pump to draw the slurry from the bottom of a tank. As the sludge particles settle, they have a tendency to bunch together and plug the discharge outlet of the tank. This feed problem is minimized by the comb shape of the auger/mixer and the screw feed of the auger.

Radon will be emitted during this operation, and appropriate radon control devices will be installed, as described in Section 5.3.5.7.

5.3.5.5.6 Thickener. The purpose of this device is to allow the flocculant, which was added in the previous stage, to take effect through the processes of time and slow agitation. The solid particles coagulate during flocculation and settle to the bottom of the thickener, and the free water lies above. This free water is pumped to the raffinate pit or the site water treatment plant, using a procedure similar to that followed for the agitated storage tank. The bottom sludge is pumped to the dewatering circuit. The types of thickeners considered include:

- Slurry tank with rake
- Inclined plates
- High-capacity thickener

These alternatives were evaluated in an MVE session (Table 5.3.5-6). The preferred alternative is the high-capacity thickener, based on the criteria developed in the MVE session. The major advantages of this alternative over the others are high capacity; ease of operation, maintenance, and flocculant addition; and the moderate cost.

The high-capacity thickener is a large-diameter tank equipped with an overflow weir and one or more bottom-discharge openings at the bottom of the vessel to uniformly draw off the settled solids. A rake inside the tank slowly rotates in the flocculated slurry to increase the packing rate and densify the solids and to keep the solids in constant agitation to allow further consolidation of the sludge. These units are designed to handle large capacities and varied feed rates (10% to 25% solids) and to operate continuously. The underflow (solids) is a dense sludge product that can be pumped directly to the CSS plant (Scenario 1, Figure 5.3.5-1) or to a mechanical dewatering unit for further water removal (Figure 5.3.5-1, Scenarios 2 and 3). Two-stage flocculation maximizes the flocculating properties of the solids producing larger and denser particles.

The central mechanism of the thickener is the head drive. These drives must operate 24 hours a day to keep the solids in constant agitation. The operating principles of high-capacity thickeners are described below.

- Feed enters a deaeration system where entrained air is removed.

- Optimum flocculation is achieved in a specially designed baffled feed-well.

- The flocculated slurry flows from the mixing chamber into the tank, where rapid solids concentration occurs. Flow from the mixing chamber contacts previously flocculated materials which enhances settling.

The advantages of high-capacity thickeners over standard thickeners are mainly the ability to optimize feed flocculation and the high-torque drive mechanism.

5.3.5.6 **Dewatering Method**. Dewatering is the final step of the seven process functions. This activity refers to the actual dewatering of the raffinate sludge using mechanical, chemical, or thermal means. Dewatering involves the separation of the sludge into two parts: one relatively solids free and the other liquid free. The different CSS and VIT feed requirements necessitate the evaluation of different types of dewatering equipment. These devices may not be the same for both plants, because the CSS and VIT feed parameters differ regarding the water content of the sludge. The types of dewatering processes evaluated consist of:

- Mechanical
- Chemical
- Thermal

These alternatives were evaluated in an MVE session (Table 5.3.5-7), and mechanical dewatering is the preferred alternative. The other types of dewatering methods are not considered practical for the raffinate pit sludge. Mechanical dewatering is preferred because of the ability to handle large volumes of sludge, ease of operation, moderate cost of equipment, and ability to control the water content of the product. Mechanical dewatering is the process where water is removed or freed from the solid phase by squeezing, shaking, pressing, sucking, or spinning. A wide variety of equipment is available for mechanical dewatering.

MVE Table 5.3.5-8, Observational Method, lists the potential deviations to anticipated conditions that may be encountered, the probability of occurrence, and the effect on the proposed design. MVE Table 5.3.5-9 identifies the additional data required to resolve some of the uncertainties or deviations related to dewatering processes.

5.3.5.6.1 **Dewatering Equipment for CSS Plant Feed.** The types of dewatering equipment considered feasible for CSS treatment include:

- Centrifuge
- Cycloning
- Vacuum filtration
- Leaf and frame press
- Screw press
- Belt filter press

Other types of mechanical dewatering equipment were also identified during the MVE session; however, other options were not considered practical for the large throughput expected for the CSS plant. These alternatives were evaluated in the first of two MVE sessions, and the preferred alternatives are the centrifuge and cyclone. The summary of the first MVE session is presented in MVE Table 5.3.5-10. Both the centrifuge and cyclone ranked equally useful, as neither demonstrated an advantage over the other. These equipment types are considered superior due to the ease of operation and the ability to control the amount of water in the filter cake. The centrifuge and cyclone were selected because, at the time of the MVE session, the sludge feed rates or throughputs had not been defined and limited data were available on the physical handling characteristics of the raffinate sludge. However, due to the limited capacity and subsequent inability of these devices to handle the CSS plant sludge feed requirements of approximately 70% to 75% water, a second MVE session was conducted, and a belt press was selected as the preferred alternative (Table 5.3.5-11).

A belt press can handle large volumes and has fewer and simpler maintenance and cleaning requirements, lower operating costs, maximum solids throughput and easy maintenance. The belt press dewatering process consists of feeding sludge onto a belt and passing the sludge through a series of rollers. As the sludge passes through the rollers, the water is squeezed out through a series of baffled compartments. This unit would best suit the needs for dewatering the CSS plant feeds because of the estimated water content of the sludge (70% - 75%). The wastewater from the dewatering process may be pumped to the site water treatment plant or back into the raffinate pit.

The hydraulic load of the solid sludges is the amount of free water retained. As sludge is fed from the thickener to the filtration equipment, water is removed. Certain types of

equipment can lower the hydraulic load of the filter cake more efficiently than others. For example, the belt expressor press can squeeze more water out of the filter cake than the standard belt press.

5.3.5.6.2 **Dewatering Equipment for VIT Plant Feed.** Different dewatering equipment was considered for the VIT treatment option because of the different feed requirements (i.e., less water in the sludge). The equipment alternatives were:

- Belt expressor press
- Frame and plate filter press
- Centrifuge
- Screw press
- Vacuum filter
- Leaf and frame filter

These alternatives were evaluated in an MVE session (Table 5.3.5-12) for processing VIT plant feed. A belt expressor press is the preferred alternative based on the criteria outlined in the MVE session. This device operates continuously, while the frame and plate is a batch-type operation. Most continuously operating devices require fewer operating personnel and less maintenance.

The belt expressor press is designed to remove more liquid and produce a filter drier cake drier than the other alternatives. The belt transporting the cake travels between a large-diameter roll and a series of smaller rolls. The action of these rollers maintains a longer contact time with the cake, which results in the removal of more water. Incorporating this piece of equipment into the batch-type process must be addressed. The belt expressor press will produce a solid cake with an acceptable water content for the VIT plant. The wastewater from the dewatering process will be pumped to the site water treatment plant or back to the raffinate pit. The tests conducted by Chen-Northern (Ref. 85) on unflocculated sludge show that vacuum filtration is a better dewatering process than centrifugation. Site test work determined that flocculation of these sludges produces an ideal dewatered product. EIMCO believes that solids flocculation would enhance any of the mechanical dewatering processes.

5.3.5.7 **Radon Emissions Control.** On the basis of on-site test results, disturbing the raffinate pit sludge will cause radon emission. Additional tests will be conducted to fully

evaluate radon emissions relating to sludge disturbance. To control or minimize radon emissions, a radon control and detection/monitoring device may need to be installed, preferably during the first dewatering unit operations (the classifier, the storage tank, and the auger or mixer). The types of radon control equipment that were considered include:

- Vapor carbon adsorber
- Molecular sieve

These alternatives were evaluated in an MVE session (Table 5.3.5-13). The preferred alternative is a vapor-phase carbon adsorber. The carbon adsorber has a higher adsorption rate per unit volume than the molecular sieve. The molecular sieve has limited removal capacities and this technology is still in the experimental stage for radon removal. Both devices have high operating costs.

The vapor-phase carbon adsorber consists of a metal cylinder loaded with activated carbon. The adsorption capacity of activated carbon is selective for radon. As the gas enters the vessel chamber, the distribution of the adsorbed radon is established along the length of the bed. A variety of carbon species have a specific affinity for radon.

Carbon adsorption is a proven technology for radon removal. Most radon control systems consist of a blower (to draw the vapors through the system), a desiccant (to remove the water from these vapors), and two carbon adsorbers connected in series to adsorb the radon. Some consideration should be given during Title II design to a positive pressure system. This alternative merits further analysis, but the radon concentration levels need to be better defined.

Water inhibits the carbon's adsorptive properties and will render the adsorber inactive. A desiccant drying unit will be required in the process train to remove water upstream of the carbon adsorber. A blower draws the radon from the trommel screen classifier, storage tank, and auger/mixer. The radon, which contains small quantities of water vapor, is pulled through the desiccant (drying agent) and the water is removed. This set-up is shown in Figure 5.3.5-2. This figure also shows the dewatering system devices selected in the previous sections and details the flow process identified in Figure 5.3.5-1.

The two desiccants considered for this application are calcium chloride and silica gel. Calcium chloride is the better of the two for this application. It is estimated that the water vapor

carry-over will be small and the usage rate low. Calcium chloride is inexpensive, readily available, and after it is spent, it can be treated in the CSS or VIT plant.

The major concerns related to the proposed radon control system include:

- Containment of radon being emitted during the dredging operation.
- Altering the design of the classifier, agitated-storage tank, and auger/mixer with venting devices to draw the radon into a central manifold and subsequently feed it to the radon emissions control system.
- Volume levels of radon will vary.

5.3.5.8 **Technical Uncertainities.** MVE Table 5.3.5-14 lists the potential deviations and effects that these system uncertainties will have on the dewatering process design. MVE Table 5.3.5-15 lists the additional data that may be required to resolve some of the problems or uncertainties related to dewatering.

5.3.5.9 **Product Discharge.** The dewatered raffinate sludge, the final product of the dewatering process, will be fed to the CSS or VIT treatment plant. This product will be conveyed from the dewatering facility to the waste treatment plant by truck or conveyor belt; the appropriate method will be selected during final design. The oversized materials collected in the classifier will be transported to the TSA or to the disposal cell. All of the free and excess wastewater removed from the dewatering process will be pumped back to the raffinate pits, transferred to the CSS plant for make-up water, or conveyed to the site water treatment plant.

5.3.5.10 **Dewatering Facility Location.** The siting of the dewatering facility was also considered. Two feasible locations were considered based on proximity to the raffinate pits and ease of transfer to the treatment plant. The alternatives considered are shown on Figure 5.3.5-3 as locations "A" and "B." The preferred alternative for the dewatering plant site is "A." This site is located in the area between the southeastern corner of Raffinate Pit 3 and the TSA. Location "B," shown on Figure 5.3.5-3, was not selected because of the greater distance to the raffinate pits.

The components of the dewatering facility can be skid mounted and, if the need arises, the plant can be moved. The size of the area required for the dewatering facility has not been determined because equipment sizes have not been specified; this will be accomplished during Title II design.

5.3.5.11 Specifications. The dewatering system specifications consist of design parameters associated with each type of device described above and any appurtenances and chemical compounds. Therefore, to develop the conceptual dewatering system described in this study, the following specifications will be required:

- Magnetic separator (optional)
- Trommel classifier
- Carbon steel agitated storage tank (optional)
- Auger/mixer
- Sludge pumps
- High-capacity thickener
- Desiccant drying unit
- Carbon adsorber unit
- Radon monitor/detector
- Air blower
- Flocculant
- Desiccant
- Belt press or belt expressor press
- Pipes, valves, gauges, and related slurry conveyance system components
- Air conduits and collectors from source area to desiccant/carbon.

5.3.6 Decontamination

5.3.6.1 General. This section evaluates methods for decontaminating the building materials derived or obtained from the chemical plant demolition and presents the conceptual design of a decontamination facility. After a review of the *Off-Site Release Guidance for Demolition Rubble and Debris From the Weldon Spring Chemical Plant and Quarry* (Ref. 86) and the *Management of Building Materials and Debris* (Ref. 87), the following materials, updated to reflect the latest quantities estimates (Ref. 104), were identified for further decontamination consideration.

	Yd^3	Tons
• Structural steel	4,500	29,800
• Railroad rails	40	265
• Plate (greater than 3/8 in. thick)	86	569
• Concrete (slabs from decks and foundations)	43,061	87,199
TOTAL (Rounded)	48,000	118,000

Preliminary radiological and chemical surveys of the buildings indicate the structural steel is contaminated with uranium and thorium. The structural steel will be cleaned to remove loose contamination prior to demolition, but the steel will still be contaminated with uranium and thorium that adhered to the metal and was not removed during predemolition cleaning.

The Project Management Contractor (PMC) tested many types and colors of paint, and lead and chromium were detected. The PMC therefore, assumes that all painted surfaces are contaminated with lead and chromium (Ref. 88). Residual waste from decontaminating the steel would be RCRA waste based on paint content.

Although the Weldon Spring steel is assumed to be surficially contaminated with uranium and thorium, in a study conducted by Bechtel National Inc., (Ref. 89) the investigators noted that scrap metal from the K-25 scrapyard in Oak Ridge, Tennessee that was initially assumed to be contaminated with uranium, was either uncontaminated or only slightly contaminated. Most surface contamination seemed to be concentrated on greasy or highly corroded surfaces or entrapped in cracks or seams within complex-shaped assemblies. The Bechtel investigators also found that edges of pieces that had been sheared or sectioned by torch cutting had a high affinity for contamination entrapment in either the folded edges or within metal that had been molten. Surfaces that were exposed to weathering for a number of years were found to be largely uncontaminated.

Similarly, the steel at the Weldon Spring site is weathered to varying degrees, and therefore, at least some of the steel is expected to be largely uncontaminated. The Bechtel finding that contamination was entrapped in edges of steel that had been sheared or sectioned by torch cutting is also relevant to how the Weldon Spring site buildings are demolished, how the steel is sized, and how the steel is scanned for radioactive contamination. Although the

MVE sessions identified only the structural steel, railroad rails, and plate steel for decontamination, other recoverable materials such as copper and aluminum can also be decontaminated in the facility.

The concrete is assumed to be volumetrically contaminated based on past site data developed from samples of scabbled foundations and on the existence of pathways promoting diffusion of contaminants from the surface into the porous concrete (Ref. 87).

5.3.6.2 **Modified Value Engineering Session.** An MVE session was held from December 2 through December 5, 1991, to determine the alternatives for further contaminant removal and size reduction of certain materials stored at the MSA prior to final disposition. After a review of the *Off-Site Release Guidance for Demolition Rubble and Debris From the Weldon Spring Chemical Plant and Quarry Report* (Ref. 86) and the *Management of Building Materials and Debris Value Engineering Study Results* (Ref. 87), the following MSA materials were identified for further decontamination consideration:

Metals

- Structural steel.
- Railroad rails.
- Plate greater than 3/8-in. thick.

Concrete

- Deck.
- Foundations.

Six alternatives were considered:

- Gritblasting with grit recovery system.
- Hydrolasing.
- Hydro metallurgy.
- Liquid abrasive blasting.
- Carbon dioxide blasting.
- No action.

The following criteria were used to evaluate the six alternatives:

- Worker health and safety.
- Effectiveness.
- Labor intensity minimization.
- Residual waste minimization.

No action was the preferred alternative for the steel. This alternative posed the least risk to workers, required the least amount of labor, generated no residual waste, created no liability issues associated with off-site release, avoided the cost of release scanning, and did not impact the final decision or schedule for the remediation of the Weldon Spring site. The disadvantages are that the materials will add to the disposal cell volume and that the metals will be lost as a resource, and violate the DOE management policy encouraging recycling.

The MVE participants presumed the concrete was volumetrically contaminated because:

- Past site data on scabbled concrete foundations indicated contamination below the concrete's surface.
- Existence of pathways within the concrete promoting diffusion of contaminants from the surface into the porous concrete.
- No data is available indicating the absence of contamination at depth.
- Surveying for radioactivity in the concrete would be difficult and labor intensive.

No practical methods to effectively decontaminate volumetrically contaminated concrete were identified. Table 5.3.6-1 presents the summary of the MVE session.

The DOE recommended that some portion of the waste be decontaminated, and in the absence of the design parameters, a backup alternative to the "no action" should be considered. Three alternatives obtained similar rankings in the MVE analysis matrix.

- Grit blasting with recovery system.
- Carbon dioxide blasting.

- Liquid abrasive blasting (liquid abrasive grit blasting).

These three alternatives were further analyzed, using the same four criteria used in the MVE session. Liquid abrasive blasting was selected as the preferred alternative based on effectiveness and safety. Liquid abrasive blasting and grit blasting are more effective on corroded surfaces and bonded contaminants. Liquid abrasive blasting generates less dust than grit blasting by using water as the abrasive carrier and is therefore more protective of worker health and safety. All three alternatives are labor intensive. Carbon dioxide blasting would generate no residual waste, but has not been demonstrated to be effective for the types of corroded surfaces present on the Weldon Spring waste. The relatively small quantity of metal (0.1% of the total Weldon Spring waste) does not justify a pilot-scale study at the Weldon Spring site to test the effectiveness of carbon dioxide blasting.

This task did not evaluate melting and reusing of scrap metal as proposed by Scientific Ecology Group, Inc. (SEG) as part of the alternatives evaluation. SEG proposed to melt the scrap and create shield blocks for use in reactors. The low levels of radiation would be of no consequence because the shield blocks become irradiated during use. SEG would return the slag generated by melting the Weldon Spring metal to the DOE for disposal.

Their services would include pickup and transportation to their smelter in Oak Ridge, Tennessee.

SEG could process a larger percentage of the Weldon Spring steel than that proposed for decontamination, because metal with minor cracks or irregular shapes that typically makes decontamination difficult does not interfere with melting. The liquid abrasion process will only decontaminate steel with largely flat surfaces and without cracks.

5.3.6.3 Functional and Performance Criteria

5.3.6.3.1 Assumptions. The following assumptions, based on engineering judgment, allowed the calculations of decontamination rates.

- 62,385 cu yd of steel is available from demolition activities.
- Approximately 60,873 cu yd of the steel will be suitable for volume reduction.

- Approximately 1,512 cu yd (10,000 tons) will be suitable for decontamination.
- All the steel is covered with a 10 mil layer of lead or chromium based paint.

5.3.6.3.2 **Functional Requirements.** The decontamination facility will clean metal with surfaces that are largely flat, for unrestricted off-site use. DOE Order 5400.5 contains radioactive surface contamination release guidelines, which are presented in Table 5.3.6-2. In addition, an ALARA (as low as reasonable achievable) process (Lytle, November 15, 1992, Appendix A) must be applied before using the guidelines in DOE Order 5400.5.

5.3.6.3.3 **Performance Requirements.** The decontamination facility will consist of one manual and two automatic chambers, which will operate one shift, 6.5 hours/day, 5 days/week. The proposed activity will be able to decontaminate 3,125 lf or approximately 70.3 tons of steel per week. Approximately 0.8 tons of spent grit and 8.3 cu ft of paint chips will be generated. The grit and paint chips will be treated (CSS or VIT) and placed in the site disposal cell.

5.3.6.4 **Regulatory Concerns.** A reduced atmospheric pressure will be maintained inside the decontamination chambers during operation to prevent the escape of particulates. Exhaust air will be pumped through a HEPA filter. The air released from the HEPA filter will be monitored to ensure compliance with State or Federal clean air regulations.

Approximately 500 gal/day of water will require treatment and disposal. The water will go either to the SWTP for treatment and discharge or to the raffinate pits for temporary storage. The wastewater will not be placed in the raffinate pits if the water contains contaminants not already in the raffinate. If the water is characteristically hazardous for lead/chromium, it will require pretreatment prior to disposal at the SWTP. The discharge from the SWTP must comply with regulations under the *Federal Clean Water Act* (40 CFR 122) and is covered by a National Pollutant Discharge Elimination System (NPDES) permit with discharge limits based upon drinking water standards, DCGs, and the ALARA process.

NRC Regulatory Guide 1.86 (incorporated in DOE Order 5400.5) identifies release standards for surface contamination. In addition, DOE Order 5400.5 requires all DOE operations to maintain radiation exposures of the public and environment to levels that are ALARA below the appropriate dose limits. A thorough description of the regulatory framework

for decontaminated materials is contained in the document *Report on Legal Basis for Expediting the D&D Program* (Hocking, October 15, 1991, Appendix A).

5.3.6.5 **Decontamination System.** Although the no action alternative was selected as the preferred alternative, this section presents a "back-up" decontamination process in the event that decontamination is mandated.

The decontamination facility will use a liquid abrasive-grit blasting system in a 40 ft x 35 ft pole barn building tentatively located north of the MSA (Figure 5.3.6-1). The building will allow scanning and decontamination activities to occur in a clean, dry environment and facilitate year-round operation. The liquid abrasive-grit blasting system is flexible, widely used in the nuclear power industry, and has been demonstrated to be capable of decontaminating most of the Weldon Spring site steel that has been identified for decontamination. The building may be purchased, constructed and operated by the PMC, or the operation may be provided by a subcontractor.

The chemical plant building demolition contractor will provide initial cleaning of structural steel to reduce dust and to minimize health hazards during building demolition. The cleaning requirements for demolition of 19 of the 31 Weldon Spring buildings (Ref. 90) are:

A. Cleaning of all visible accumulated dust, dirt, and flaking rust from surfaces of structural members, interior walls, and decks following Section 02055, Part 3.04 activities, prior to structural dismantlement and demolition, as specified in Section 02055, Part 3.05.

B. Cleaning will begin at ceiling level and work down to the floor. One or more of the following alternate methods, approved by contractor, will be used.

1. Manual cleaning alternative includes:

- Removing loose dust by HEPA vacuuming or wet wiping.

- Removing compacted dust by scraping or brushing simultaneously with HEPA vacuuming, followed by wet wiping. Detergents may be used after receiving approval from contractor.

- All dust and materials used to remove dust will be bagged and sorted as non-metal debris.

2. High-pressure water alternative includes:

   - Sealing building openings in sidewalls and roof with 6-mil plastic sheeting if doors, windows, or other coverings are missing. Intermediate supports shall be installed as necessary to prevent wind damage to plastic sheeting.

   - Using plastic sheeting or approved equal material on floor at interior perimeter, where necessary, to prevent water from exiting building at ground level.

   - Wet vacuuming or collecting runoff in existing cleaned sumps reopened for this purpose and pumped continuously.

   - Pumping sludges and spent water to subcontractor-supplied water tank for disposal by subcontractor in raffinate pit.

   - Spraying equipment shall have capacity for adjustable pressure up to 750 psi and adjustable discharge volume to minimize water use to the quantity necessary for surface cleaning.

The subcontractor will place the structural steel suitable for decontamination in the northern section of the MSA, identified in Drawing 3589D-CP-50753 (Ref. 90).

Plate steel more than 3/8 in. thick will be cut into approximately 4 ft x 8 ft pieces and stored in the nonshreddable pile in a northern section of the MSA. The structural steel will be placed in the MSA in 30-ft lengths (maximum) by the demolition contractor (Ref. 88). As part

of the decontamination, the structural steel would be cut into 12-ft maximum sections with a mobile shears. Railroad rails will not be size reduced.

The 12-ft sections will be transported to the staging area where they will be inspected for cracks and scanned using a Geiger Mueller (GM) or alpha scintillator radiation detectors. The survey instruments will be operated in accordance with procedure ES&H 2.6.3s, *GM Detector Calibration, Operation, and Usage* and ES&H 2.6.1s *Alpha Detector Calibration and Operational Check*.

Steel that is visibly cracked or damaged so that scanning for radioactivity would be ineffective, will be transported to the MSA for temporary storage or directly to the disposal cell for burial. Steel in good condition and demonstrated by the scanning process to be uncontaminated will be transported directly to a staging area outside the site boundary for pickup by a scrap steel recycler. Steel that is scanned and found to exceed clearance criteria will be processed in the liquid abrasion decontamination facility. Specific sections of obnrate contamination may be cut from steel beams to allow the remainder to be decontaminated and recycled. A statistical survey procedure similar to that proposed by Green, Miller and Nelson (Ref. 91) will be used to ensure that released material is uncontaminated.

Contaminated steel will be processed in the decontamination facility which will have three chambers operating concurrently. One chamber will contain a 7 ft x 15 ft laydown area and a single hand-operated liquid abrasion nozzle for steel that is bent or shaped so that an automated system would be ineffective.

The other two chambers would be automated and fitted with 10 to 12 liquid abrasion nozzles. Steel would travel through the decontamination chamber on a conveyor and be cleaned by stationary liquid abrasion nozzles. The nozzles would be adjustable to accommodate the various sizes and shapes of steel. The decontamination building will be fitted with hoists for handling the steel. The heating, cooling and ventilation systems in both chambers discharge through a HEPA filter, although airborne activity should not be a problem due to the nature of liquid blasting and rinsing.

Each liquid abrasion nozzles cleans at a rate of approximately 0.5 cu in./sec or 12.5 sq ft/hour. The combined facility can process approximately 312 sq ft/hour of steel. However, the nozzles may operate further from the target steel with a wider swath and a faster

cleaning rate if the contaminants do not adhere tightly to the steel. Each nozzle requires 10 to 12 horsepower and generates approximately 2 lb/hour of spent grit.

Decontaminated steel would be scanned with a Geiger-Müeller (GM) or Alpha detector and cleared for off-site release. Rather than spending time trying to clean stubborn contamination, steel that fails scanning will be transported back to the MSA and identified for disposal in the disposal cell or will be transported directly to the disposal cell.

All waste material and wash water are collected in a sump beneath the decontamination chambers. The water will be transported to the SWTP and the sludge transported to the treatment facility.

5.3.6.6 Uncertainties. The PMC does not have an accurate estimate of the surface area of the steel that will require decontamination. In addition, the demolition subcontractors will clean the structural steel before the buildings are demolished, and some unknown quantity of the steel will probably meet the clearance criteria without additional decontamination. Also, some quantity of steel will be unsuitable for decontamination. Two buildings will be demolished with a wrecking ball clam shell bucket, shear and torch. The rest will be demolished by selectively cutting members and pulling the building over. The resulting bent or damaged steel will make scanning for radioactivity difficult. Contaminants accumulated in the cracks or entrained in the metal matrix by cutting with a torch or shears will not be detected by the scanning equipment. In addition, bends in the steel will make automated decontamination difficult, requiring more time.

The residue generated by grit blasting of lead- or chromium-containing paint may be a characteristic RCRA waste. It is assumed that all painted surfaces are lead and chromium contaminated (Ref. 88). Treatment of the residual waste would be required before disposal.

The quantity of paint and spent grit residual waste cannot be accurately estimated. A hydrocyclone removes the spent grit and contamination debris from the process water. The quantity of paint chips will depend on the amount of steel that is painted and the thickness of the paint. The quantity of the spent grit will vary with the quality of the surface of the steel being decontaminated, and the quantity and persistence of contamination. The size of the decontamination facility and the number of decon chambers should be reconsidered when the quantity of steel and the degree of contamination is better defined.

For the purpose of this evaluation, EPA and DOE regulations are assumed to allow decontamination and off-site release of radioactively contaminated materials.

5.3.7 Additional Treatments

5.3.7.1 General. This section discusses the treatment methods (other than CSS or VIT) that may be required for certain types of wastes. Five groups of wastes that were not addressed in Sections 5.3.2 and 5.3.3 include:

1. Various solid and liquid RCRA hazardous wastes reported in the waste inventory tracking system (WITS) and stored in Building 434.

2. PCB-contaminated soils, sludges, liquids and containers reported in WITS and stored in Building 434.

3. Cooling tower wood, preserved with chromated copper arsenate salts.

4. Water treatment plant sludges.

5. TBP liquids contaminated with mercury and PCBs.

Land disposal restrictions apply to most of the wastes described above, requiring either (1) treatment to achieve a concentration-based standard or a technology-based standard, or (2) an EPA Regional Administrator waiver to allow alternative treatment and disposal. Unlike previous TID sections that described an active alternative selection process, this section summarizes the findings of past studies and reports the applicable treatment standards in RCRA or TSCA regulations.

Information reviewed included *Supporting Study 41, Pretreatment Technologies Evaluation* (Ref. 91); the database contained in the Alternative Treatment Technology Inventory System (ATTIC) (Ref. 93); and DOE waste handling practices at other sites.

5.3.7.2 Summary of Additional Treatments. The release of material or waste off-site is allowed for off-site recycle and reuse if detectable radiation levels are within the *Off-Site Release Guidelines* (Powers, July 31, 1992, Appendix A) and DOE Order 5400.5, *Radiation*

Protection of the Public and the Environment. However, the effort required to demonstrate that a material or waste satisfies off-site material release guidelines (by statistical analysis and comparison) is extensive and is not cost effective for small waste volumes if on-site waste disposal options are available. Wastes characterized as virgin materials are potential candidates for recycle and reuse because of relative waste release requirements.

Liquid mixed wastes having heat content greater than 5,000 Btu/lb and water content less than 10%, such as oils and solvents, should be considered for energy recovery. Energy recovery systems that burn mixed waste are presently operating and several new systems are expected to be permitted and operational by 1994 (e.g., Diversified Scientific Services Incorporated and SEG).

RCRA mixed-waste landfills and incinerators are very limited at this time and there are few operating sites, but several organizations are pursuing permits and facility designs. Also, there is presently no TSCA mixed-waste landfill in operation, requiring all TSCA-mixed wastes to be incinerated, treated, or stabilized before landfilling. The backlog of DOE RCRA and TSCA mixed-wastes requiring treatment and disposal is extensive. Therefore, if on-site treatment alternatives are not provided, extended on-site waste storage will be required.

Supporting Study 41 examined several treatment alternatives for the waste groups:

- **RCRA solid wastes stored in Building 434**. *Supporting Study 41 - Pretreatment Technology Evaluation* (Ref. 92) considered some of the RCRA solid wastes acceptable as vitrification feed stock material if the wastes were properly blended with a silica base. Waste size reduction was recommended to improve material handling. RCRA solid wastes also could be directly used as CSS feedstock, but waste size reduction and blending would ensure a consistent solidified matrix. The study recommended no additional pretreatment, other than size reduction, prior to VTT or CSS.

- **TSCA (PCB) wastes stored in Building 434**. Thermal destruction of PCBs is a proven technology and *Supporting Study 41* (Ref. 92) recommended further pursuit of off-site incineration. The ash residuals would be returned to the site for further treatment by CSS or VIT. VIT would thermally destroy PCBs, but the concentrations

in the products of incomplete combustion are not known, requiring a VIT treatability test to demonstrate the destruction removal efficiency for PCBs.

Supporting Study 41 (Ref. 92) also reports that treatability tests were necessary with the CSS process and using PCB-contaminated soils from the site to determine if CSS would immobilize the PCBs. The effort associated with the two above-described treatability tests was not considered cost effective and was not recommended in the study.

- **Arsenic-contaminated wood.** *Supporting Study 41* reports that both VIT and CSS are acceptable treatment alternatives to stabilize and solidify arsenic salts "fixed" in the preserved wood. *Supporting Study 41* further recommends shredding or chipping the wood before treatment to improve material handling and provide a more uniform feed. Wood can be directly fed into the VIT system, but must be blended in the CSS process at a recommended weight ratio of one part wood to three parts feedstock.

  Bioremediation was eliminated as a viable treatment alternative because of the toxicity effect that copper and arsenic have on the enzyme reactions of microorganisms during wood decomposition. Incineration is the recommended BDAT for arsenic-preserved wood; however, off-site shipment and the availability of incineration discourages further consideration.

- **Water treatment plant sludges.** *Supporting Study 41* recommends that water treatment plant sludges be characterized in accordance with the TCLP. Heavy metals in the sludges are expected to be primarily metal hydroxides and should be treatable by either the CSS or VIT process, if the sludge is properly blended with other feedstock material. Pretreatment of water treatment plant sludges was considered not cost effective.

- **TBP liquids contaminated with mercury and PCBs.** No treatment or disposal alternative for tributyl phosphate was discussed in *Supporting Study 41*.

Treatment recommendations reported in *Supporting Study 41* do not consider the land disposal restrictions. Upon further review of the regulatory requirements (concentration-based and technology-based treatment standards), it was found that several recommendations required

an EPA Regional Administrator waiver or that the recommended treatment process was not readily available.

Additional review of regulatory requirements and technology performance studies have refined potential and available treatment alternatives to include the following:

- **RCRA solid wastes stored in Building 434.** Treatment standard requirements can generally be achieved with existing or proposed on-site treatment systems, minimizing waste handling and disposal efforts at the CSS or VIT facilities and reducing cell capacity requirements. However, macroencapsulation (BDAT for elemental lead) and incineration (BDAT for high total organics) are not readily available on or off site; therefore, EPA Regional Administrator approval must be solicited for alternative treatment processes if on-site vitrification is not provided.

- **TSCA (PCB) wastes stored in Building 434.** Incinerating PCB- contaminated soils, sludges, and liquids in the DOE's Oak Ridge incinerator will probably not be a viable option until the late 1990s because of existing commitments with other off-site generators. Therefore an extension of the existing storage prohibitions and/or alternative treatment processes will be required. On-site vitrification would achieve the treatment standard of 99.9999% PCB destruction removal efficiency, but a trial burn must be conducted to verify the DRE.

  PCB dehalogenation is emerging as a viable PCB destruction process. Several patented chemical process using the alkaline, sodium, or potassium polyethylene glycolate processes (alkaline polyethylene glycolate [APEG], sodium polyethylene glycolate [NaPEG], or potassium polyethylene glycolate [KPEG]) have demonstrated PCB destruction levels between 75% to 90%. These processes show great potential for on-site destruction of PCB-contaminated liquids, soils, and sludges without extensive capital expenditures and would allow the solids to be directed to the CSS or VIT systems.

- **Arsenic-contaminated wood.** Given the relatively low arsenic TCLP concentrations (a maximum concentration of 11.2 ppm), CSS will easily meet treatment standard requirements and allow the end product to be buried. Since the chromated copper arsenate salts react with the wood substrate and are "fixed" in a highly insoluble state

on the wood surface, milling the wood surface would separate the arsenic-contaminated wood substrate from the arsenic-free wood and reduce the volume of arsenic-contaminated wood requiring stabilization. Arsenic-free wood would be composted.

- **Water treatment plant sludges.** The SWTP Train 1 and 2, the quarry water treatment plant, and the mobile sump water treatment system have similar heavy metal precipitation processes: chemical addition and mixing (lime or polymers), coagulation/clarification, and filtration.

  These processes should generate sludges of similar character. To date, the sludges that have been characterized have been determined to be nonhazardous, but this determinatin could change. Heavy metals in the sludges are expected to be primarily metal hydroxides and should be treatable by CSS or VIT.

- **TBP liquids contaminated with mercury and PCBs.** Approximately 7,400 gal of TBP were identified in two vessels on site: WITS 130 and 131. The TBP was transferred to 55-gallon containers in April and May 1993. TBP was noted to fail the TCLP test for mercury and contains greater than 50 ppm PCB. The land disposal restriction treatment standard for liquid hazardous wastes having greater than 50 ppm PCB is incineration; therefore, all other treatment and disposal alternatives must be approved by the EPA Regional Administrator or included in the ROD as an ARAR waiver. The ROD and the *Conceptual Site Treatment Plan* list wet oxidation as the preferred technology (Ref. 3).

5.3.7.3 Treatment Recommendations. Considering the treatment standards for the five waste groups and findings from past studies, Tables 5.3.7-1, 5.3.7-2, 5.3.7-3, and 5.3.7-4 summarize and report the treatment and disposal alternatives that minimize waste handling and disposal efforts at the CSS or VIT facilities and reduce landfill capacity requirements. Many of the containerized hazardous wastes stored in Building 434 have multiple hazardous waste constituents (codes) requiring more than one treatment standard to be met for a single container.

Table 5.3.7-2 describes treatment alternatives for containerized wastes reported in the WITS Land Disposal Restriction Table, (Uhlmeyer, September 9, 1992, Appendix A). A typical

example of multiple waste constituents is paint sludges that were found to contain high total organics and heavy metals. Incineration or vitrification is recommended for paint sludges, rather than attempting to treat and remove each heavy metal from the paint sludge. Tables 5.3.7-3 and 5.3.7-4 describe treatment alternatives for PCB-contaminated materials, cooling tower wood, and water treatment plant sludges.

5.3.7.4 Technical and Regulatory Uncertainties. Technical and regulatory uncertainties must be considered to ensure waste disposal is achieved within the framework of regulatory requirements, and yet does not interfere with the overall progression of the project. Uncertainties include:

- Accurate waste characterization requires an ongoing waste characterization program for existing and newly generated wastes. Immediate waste characterization data required include chemistry of water treatment plant sludges; radionuclide levels for containerized wastes; absolute mercury concentrations for mercury-contaminated wastes; and total organic, heat, and water content for wastes having more than 1% total organic carbon.

- Containers with more than one hazardous waste constituent (multiple hazardous waste codes) will require treatment that is compatible with all applicable treatment standards.

- Bench-scale treatability testing of RCRA wastes stored in Building 434 must be conducted to develop optimum contaminant and reagent reaction mixtures, to identify potential chemical reaction interferences, and to estimate resin or filter performance levels.

- Full-scale on-site or off-site resin encapsulation systems are not currently available for lead treatment. Current thought is that CSS provides adequate macro encapsulation/stabilization for lead-based contamination.

- On-site PCB treatment alternatives are recommended but must be approved by the EPA Regional Administrator. Off-site PCB treatment (since not readily available) would require extended on-site storage.

- All PCB-contaminated soils will be treated to effective treatment levels that are approved by the EPA Regional Administrator and the Missouri Department of Natural Resources.

- Chemical treatment of PCB-contaminated sludges and paints will experience reaction interference, likely limiting treatment and disposal option to incineration. Laboratory treatability testing of PCB-contaminated sludges and paints is crucial for an on-site treatment alternative evaluation.

- A bench-scale treatability study is needed to determine if milling the cooling tower will economically reduce the arsenic-contaminated wood volume requiring treatment.

- Availability of and access to off-site treatment and disposal facilities will likely affect the overall site treatment and disposal schedule.

- Extended temporary on-site storage requirements and associated regulatory approval and waivers are dependent upon the waste treatment and disposal schedule.

5.4 Site Closure

5.4.1 General

Site closure refers to those activities which follow completion of the disposal cell. It includes the removal of temporary support facilities that supported construction or treatment operations, the removal of the temporary haul and access roads, and the design and layout of final roads, site reclamation, groundwater monitoring wells, and surface runoff control structures that will remain after site closure. Also discussed are conceptual requirements and, in some cases, conceptual designs for structures such as monitoring wells and roads that will be required prior to closing the site. Following closure, the long-term monitoring and maintenance requirements will be detailed in a post-closure plan which conforms with the ARARs.

The proposed layout of site structures at completion of the remediation activities (prior to the site closure tasks) is shown in Figure 5.4-1. The disposal cell will be near completion, and no additional cell closure design elements will be required. The site closure activities presented in this subsection pertain to areas outside the cell perimeter. Some of the removal

activities discussed such as the demolition and removal of the waste and water treatment plants, may be performed during waste excavation and removal activities or as part of a final remediation task prior to site closure. Nevertheless, these removal activities are addressed as part of site closure because they are not fully addressed in the other CDR tasks.

Because some temporary facilities, such as the TSA, decontamination pads, waste treatment plant, SWTP, and some roads will have contaminated components (liners, foundations, soil, and other various materials) requiring disposal in the on-site cell, the site closure task will consist of two phases: (1) prior to cell closure, for those activities that will require placement of contaminated components within the cell, and (2) post-cell closure, for the remaining activities required to transition the site to its final condition. This second phase assumes that no contamination remains outside the cell. The removal of the contaminated temporary facilities and dirty roads could be incorporated in the waste excavation and removal activities, thereby defining site closure as those activities that do not involve contaminated materials. This issue may be resolved prior to or during final (Title II) design.

The basic assumptions for site closure are:

- Known contaminated soil areas within the site have been excavated and the contaminated soil and materials have been placed in the disposal cell.
- Excavations have been backfilled.
- Contaminated and possibly a few noncontaminated components of the waste treatment plant and the SWTP will be dismantled and placed in the disposal cell.
- Some support facilities have not been removed.
- Building 434 has been dismantled.
- The haul and access roads used during construction have not been removed.
- Areas in the vicinity of the disposal cell have been graded to allow for surface water drainage.

Based on these assumptions, the following topics are addressed as site closure activities:

- Removal and remediation of temporary support facilities.
- Removal of temporary roads and the establishment of final site roads.
- Site reclamation.
- Groundwater monitoring wells.
- Surface runoff controls.

The specific design criteria, plans, and specifications required for each of the proposed designs or functions related to site closure are identified in each subsection. General specifications are listed in Section 5.4.7. New or additional concepts developed after the completion of this conceptual design may be detailed and incorporated in the final design stage (Title II). The function of site closure is discussed below.

Site Closure Functions

RCRA closure requirements (40 CFR 264, Subpart G) will apply to the following facilities: Building 434, TSA, water treatment plant storage areas and equalizaiton basins, and the asbestos storage area (ASA). RCRA closure requirements have been determined to be relevant and appropraite for the raffinate pits. Additional closure requirements are included under 40 CFR 264.178, 40 CFR 264. 228, and 40 CFR 264.258.

RCRA post-closure policies (40 CFR 264, Subpart G) require that post-closure care continue for 30 years after site closure, and that post-closure use of the property must be restricted in a way that prevents damage to the cell cover. The design life of the cell is 1,000 years to the extent reasonably achievable and, in any case, at least 200 years [40 CFR 192.02(a)].

The proposed final site condition must provide for several functions including:

- Site access for monitoring and maintenance.
- Low to no maintenance requirements.
- Protection of the disposal cell, including:

- Protection of cell cover from intruders.
- Protection of the environment from cell cover rupture.

- Eventual transformation of site back to a natural state.

The final layout of the site will require access to monitoring points and a security fence and entrance control point to the cell area for a minimum 30-year monitoring period for maintenance activities at the disposal cell and vicinity. The functional and performance requirements for the following site closure activities are presented in Section 6.4.

5.4.2 Removal and Remediation of Temporary Support Facilities

The temporary facilities that were constructed to support the remediation program will be removed or demolished during the first phase of site closure, if plans for their removal are not addressed in previous remediation activities. The components of the demolished facilities and any contaminated materials encountered during the demolition can be stored during the final phase of cell closure. The locations of the temporary support facilities are shown on Figure 5.4-1.

Identification of Alternatives

Various alternatives have been identified for the ultimate disposition of the temporary support facilities. Contaminated structural foundations, storage pads, equipment, and materials will be removed and placed in the cell. The remaining uncontaminated materials may be disposed of by implementing one or a combination of the following five alternatives:

- No action.

- Remove and place in the disposal cell.

- Remove and release off site.

- Rubblize subgrade materials in place and cover with topsoil.

- Remove subgrade materials, rubblize, and reuse as aggregate for road base and possibly drainage riprap.

Evaluation of Alternatives

The five alternatives were evaluated in an MVE session, the results of which are summarized in Table 5.4-1. The preferred alternative is to remove, rubblize, and reuse the materials as aggregate for road base or drainage riprap. This alternative was selected based on the criteria listed in the table: public health and safety, reducing the required cell capacity, salvaging and maximizing reuse of materials, reducing unnecessary and costly off-site release and disposal, and reducing the need for purchasing site closure materials. If this material is not suitable for use as riprap for long-term erosion protection, it may be necessary to import some material. The use of this material for road base, however, is more practical. The major advantages of this alternative over the others are that it decreases the volume of material requiring disposal and reuses the material, thus eliminating the need to purchase and import additional material.

The no action alternative (Alternative 1) is not considered viable because the site is to be returned back to its natural state. Portions of the site outside of the disposal cell may be returned to the military training area or to the wildlife areas. If materials were removed and placed in the cell (Alternative 2), a portion of the cell would have to remain uncovered following completion of most construction activities, or these facilities could be removed during the last stages of cell completion. A disadvantage of this alternative is that it increases the required cell capacity and clean material would also be placed in the cell. Temporary support facilities may also be removed, inspected, and released off site for reuse or shipped to a local landfill (Alternative 3). A disadvantage of this alternative is that some materials may be contaminated and not releasable; for releasable material there are costs associated with testing these materials to ensure they meet stringent off-site release criteria.

Concrete, asphalt, aggregate, and other similar materials may be rubblized, left in place, and covered with topsoil (Alternative 4). This appears to be a viable alternative since it may help to reduce the need to import fill dirt. Asphalt should be tested to ensure that no contaminants would be released into the soils. However, rubblizing materials and leaving them in place with a soil cover serves no purpose other than hiding the materials. In future years,

portions of the site may be used for other purposes and it would be undesirable to have this material in the soil.

Alternative 5 specifies that concrete, asphalt, aggregate, and other similar materials may be removed, rubblized, and salvaged for reuse as backfill material, roadway base material, or drainage riprap. All reinforcing steel would be removed from concrete prior to reuse. The reinforcing steel would be disposed of off site. Concrete may be well suited for use as riprap because of the angular shapes; it could also be easily rubblized to the desired size. Asphalt may be most amenable for reuse as roadway base or surfacing materials. Aggregate materials could be reused for drainage or roadways. The best use for each of these materials should be determined during final design. Other uncontaminated materials that cannot be reused as aggregate, such as metals, glass, and plastics, would be inspected, segregated, cleaned (if necessary), and released off site.

Details of the Preferred Alternative (Alternative No. 5)

The reuse of uncontaminated materials as aggregate for road base and drainage riprap will maximize the use of this material by not increasing the required cell capacity and by serving two functions: as foundation and as aggregate. The temporary support facilities will be removed following procedures similar to those used to remediate (building removal) the site. The contaminated components will be hauled to the cell for disposal. Standard methods and equipment may be used to dismantle, demolish, and remove these facilities. Subgrade materials such as building foundations, concrete, asphalt pads, and roads may be broken up with standard construction equipment. Crushers, shredders, or other devices may be used to reduce rubble to the desired sizes for reuse. Timber materials may be shredded for compost or mulch. All materials should be inspected prior to off-site release.

Potential deviations from the expected conditions are listed in MVE Table 5.4-2. These potential deviations include encountering contaminated subgrade materials and encountering materials that are not suitable for road base or drainage riprap. Both of these potential deviations have a low to medium probability of occurring. The effects these unexpected conditions will have on design are listed in MVE Table 5.4-2.

Following is a list of the drawings and specifications that may be required for the removal and remediation of the temporary support facilities:

- Removal Design Drawings

  - As-built facility drawings.
  - Foundation excavation plans and details.
  - Rough grading plans.
  - Temporary erosion and sediment control plans and details.

- Specifications

  - Temporary erosion and sediment control measures.
  - Building dismantlement and removal.

Technical Uncertainties

An uncertainty that may affect the alternative selected involves the potential for encountering contaminated materials after the disposal cell has been closed and sealed. If this situation occurs, it is conceivable that only small quantities of contaminated material will be encountered and therefore, because of the small quantity, the materials may be sent to an off-site disposal facility.

5.4.3 Site Closure Road System

Development of the post-closure site road system includes removing all temporary roads used during disposal facility construction and other site remediation activities, reconditioning roads that will remain after closure, and constructing new roads. Figure 5.4-1 shows the locations of current roads. The entrance road and any road that follows the perimeter of the cell will remain for incorporation into the final site road layout. The current site perimeter road may also remain; this will be decided during final design.

Post-closure roads will provide access to various site locations for maintenance and monitoring purposes. Roads will be designed and maintained for the life of their respective use. The final road system should include the following:

- Entrance road and parking lot.
- Disposal cell perimeter service and maintenance road.
- Environmental monitoring access service roads, if required.

The following information is relevant to the design of a post-closure site road system:

- Site access locations.
- Final disposal cell location and configuration.
- Locations of monitoring stations and other facilities to remain on site.
- Frequency of use.
- Types of vehicles to use road system.
- Design life and weather conditions.
- Operation and maintenance activities.

Identification of Alternatives

The site road system is limited to access routes for maintenance and monitoring points, therefore, a cell perimeter road would provide convenient access. There are no alternatives to the layout of the cell perimeter road; this road will be constructed around the perimeter of the cell. The selected alignment of the cell perimeter road may depend on the location of the monitoring stations. The layout of the site access road should include existing roads to the extent possible. If required at a later date, road spurs from the cell perimeter road may be constructed to access selected monitoring points or the leachate collection basin within the cell security fence. Conceptual designs for the site roads are presented in Section 5.1.5. The layout of the site closure road system is presented in Section 5.4.4 and is illustrated on Figure 5.4-1.

The alternatives considered under site closure are confined to the type or design of road sections that may vary from the designs proposed in Section 5.1.5. These include widths, surfacing type (asphalt, concrete or rubble) and thickness, base type and thickness, and drainage culverts or road dips. These alternatives are largely dependent on road purpose, vehicle types and loads, design life, and frequency of use. A design load of 2,000-lb axle loads was selected; higher loads would be infrequent.

Evaluation of Alternatives

The alternatives were evaluated in an MVE session, the results of which are summarized in MVE Table 5.4-3. The preferred alternatives selected for post-closure site road designs are listed in Table 5.4-3 and discussed in the following sections. These alternatives were selected based on the criteria listed in the table: serviceability during at least a 30-year period, maintenance requirements, and cost.

Road width will be 12 ft for single-lane traffic; where existing roads are used, the existing width may be maintained. Road width selection also considered the types and numbers of vehicles using the roads. Standard pick-up trucks were assumed to be the main users, at one per day. Well drilling vehicles, water trucks, or backhoes will also occasionally travel the roads.

The selected road surface material for the entrance road is asphalt. The existing road has an asphalt surface; replacing the surfacing would not be cost-effective or logical. Serviceability of asphalt roads is good, with minimal maintenance requirements. Gravel roads were selected for the cell perimeter road because of the infrequent use, and because gravel will provide sufficient serviceability over a 30-year period. Occasional maintenance and mowing or spraying of grass in the road once or twice a year will be required. This maintenance can be performed semiannually to coincide with the semiannual monitoring requirements discussed in Section 5.5. Dust and erosion will be minimal if large aggregate is used for the surface. The cost of constructing a gravel road is minimal. Road surfacing materials and thickness are based on types of vehicles, design loads, and usage. The alternative surfacing types for the cell perimeter road are asphalt, concrete, and gravel.

Asphalt provides a clean, smooth, durable surface material which should last for at least 30 years. It is inexpensive and requires minimal maintenance. Cracking caused by moisture and temperature differentials can be expected, but should not hinder traffic. Grass may grow through the cracks, but this could be resolved by spraying if desired. The asphalt and base thicknesses for standard vehicle loads should be the same as local county road standards.

Concrete also provides a clean, smooth, durable surface and will last for at least 30 years. Concrete roads are fairly expensive to construct, but require minimal maintenance. Some cracking caused by moisture and temperature differentials can be expected, but this should

not hinder traffic. Grass may grow through the cracks, but could be sprayed if desired. Concrete surfacing should be a minimum of 4 in. thick with a minimum gravel base of 6 in. The final road design should be analyzed during Title II design.

Gravel roads are fairly smooth, but may create some dust when dry, can be eroded, and may not last for 30 years. They are inexpensive to construct and require only periodic maintenance. The rubble from the demolished temporary facilities may be used in addition to gravel. Grass may grow in the roadbed if the road is used infrequently.

Determining whether to use culverts or to provide road dips was based primarily on serviceability and maintenance requirements. Drainage culverts were selected over fords (low drainage crossings or dips) because of low capital and maintenance costs and better operational aspects. Serviceability and maintenance is expected to be good if the culverts are designed to be large enough to pass the design storm event, allowing clearance for minor debris. Cost may be comparable to a road dip since special road surface treatment would be necessary to minimize the effects of erosion and rutting. Culverts can provide good drainage flow without erosional effects. If designed large enough to adequately pass the design storm and minor debris, the culverts will require only occasional inspection and minimal maintenance. Road dips will provide good drainage flow but could possibly erode road surfacing. Surfacing would require special paving, such as concrete or riprap treatment in the dip, and could require substantial maintenance.

Details of Preferred Alternatives

Post-closure road design should follow county road design standards at a minimum. Gravel roads should have a minimum of 4 in. of minus- 3/4-in. over 8 in. of minus- 4-in. material. Rubblized material from the demolition of temporary facilities may be used for the minus- 4-in. material. The final design should be analyzed during Title II design. No new asphalt road construction is anticipated.

The largest vehicles anticipated to travel site roads during post-closure are a well drilling rig and a water truck. Repair to the cell cover, if damaged, may be performed using smaller equipment such as a backhoe with a bucket. All roads will be designed with drainage ditches, where required.

MVE Table 5.4-4 lists the potential deviations to the expected conditions for the site roads system design. These deviations are related to deterioration and erosion. The probability of these conditions occurring is low to moderate, and no fatal flaw was encountered. The effects on design are also listed in this table.

Road design criteria, drawings, and specifications for road removal, modifications, and new construction are listed below:

Site Road Design Criteria

- Demolition and removal of existing roads.
- Grading and subgrade preparation.
- Aggregate road materials.
- Asphalt surfacing.
- Road signs and markings.
- Design road minimum requirements (Table 5.4-5).

Site Road Drawings

- Existing site roads plan.
- Post-closure site roads plan.
- Site roads plans, profiles, sections, and details.
- Road signs and markings.

Site Road Specifications

- Temporary erosion and sediment control.
- Demolition and removal of existing roads.
- Grading and subgrade preparation.
- Aggregate road materials.
- Asphalt surfacing.
- Road signs and markings.

Drainage culverts should be designed to accommodate the post-closure design storm event and provide adequate freeboard for minor floating debris. Sufficient embankment protection at

culvert inlets should also be provided to minimize erosion and the need for maintenance. Section 5.4.6 describes the surface runoff controls, and Section 5.1.6 provides details on site drainage.

Technical Uncertainties

This study assumes that no road spurs will be provided to monitoring wells installed either on site or on vicinity properties. The current site perimeter road may remain, but it is located outside the cell perimeter fence. If this road remains, some restoration and subsequent maintenance will be required by the custodian of the site.

5.4.4 Site Reclamation

Reclamation is defined as the creation of a stable ecosystem capable of maintaining itself on a previously disturbed site. Restoration, which is the reproduction of previously existing ecosystems on disturbed lands (i.e., climax hardwood forest and tall grass prairie that existed before European settlement) is not addressed. Achieving restoration is nearly impossible at any site; it would require rebuilding the soil and the use of only native plants and animals to repopulate the site (Ref. 94 and Ref. 95).

Site reclamation involves those measures implemented at the surface in the vicinity of the disposal cell that provide additional safety protect the public and to maintain the integrity of the cell while providing the aesthetic component. For this study, site reclamation for the final site condition included revegetation and site security (including fencing). Other topics also pertaining to final site conditions, such as the final road layout, were discussed previously.

5.4.4.1 Revegetation. A major component of reclamation is the revegetation of the Weldon Spring site. The basic function of the vegetative system is to prevent soil erosion and to provide a system that will ensure long-term stability with little or no ongoing maintenance requirements. Native plants (mainly grasses) are a possible choice for this purpose and are being proposed as the best alternative for site closure. Native grasses will meet the functional requirement because of the following attributes:

- Native to the area; therefore, able to survive environmental extremes including drought, freezing, insect attacks, fire, and herbivore.

- Reduces erosion potential due to deep and extensive root network, absorbs and transpires large amounts of rainwater, has high tensile strength even when the aboveground plant is dormant, and enhances the development of stable soil aggregates (Ref. 96).

- Creates a stable environment which resists invasion by weeds or other, less desirable plants.

It is assumed that all chemically contaminated or radioactive soil has been removed prior to the site closure phase. Clean fill soil may be brought in from off site, or may be moved from an on-site location; clean in-place surface or subsurface soils may also be used. Whatever the source, all soils intended for reseeding will be in a condition (including texture, pH, nutrients, compaction) that is supportive of plant growth or will be treated (plowed, cultivated, amended) to support plant growth. Soils will be free of rubble and debris to the extent practicable.

It is also assumed that the site will remain in public ownership. To date, no specific ecosystem requirements (such as wildlife habitat or cultural purposes) have been identified by either the DOE or public or private organizations therefore, no special wetland reclamation or mitigation plans for the site are proposed in this study.

Identification of Alternatives

MVE Table 5.4-6 lists the alternatives for the vegetative cover for site closure. The primary criteria used to evaluate the alternatives were minimization of maintenance, protection from erosion, aesthetics, and ease of establishment. The major advantages and disadvantages of each alternative were evaluated.

Evaluation of Alternatives

Determining the final vegetative cover involved the selection of either a mix of native, perennial warm-season grasses (those that conduct most of their growth in the summer months) or a mix of introduced (non-native) perennial cool-season grasses (those that grow the most during the spring and early summer months). MVE Table 5.4-6 lists the advantages and disadvantages of both potential seeding mixes. In either case, minor amounts of native or introduced legumes (clovers, vetches) will be included in the seed mix. The preferred

alternative is native prairie grasses. Species such as big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), little bluestem (*Schizachyrium scoparium*), and sideoats grama (*Bouteloua curtipendula*) are typical grasses native to Missouri (Ref. 97) which should be included in the mix.

Whatever the selected species mix, the site topography should be restored to a condition similar to its pre-development condition. Final grading should be planned to blend with and resemble the existing local topography of gently rolling hills. Final slopes should be designed to allow use of mechanized seeding equipment.

Either native or introduced grasses can be used to vegetate drainage ways on the site. Drainage ways that are to be vegetated should be designed to withstand acceptable water flow velocity for the species planted. Areas that will require ongoing maintenance (mowing) following site closure, such as road berms, should be designed to allow future access by maintenance equipment. Either native or introduced grasses could be used to vegetate these areas.

Although site closure will be engineered and implemented following the completion of construction activities, various areas will be seeded and sodded following incremental remediation and construction activities. It is assumed that these previously planted areas will be purposely disturbed during site closure activities.

Details of Preferred Alternative

The advantages of planting native prairie grasses at the Weldon Spring site outweigh any disadvantages. Several important issues are briefly discussed below.

There is a growing movement to preserve and recreate natural ecosystems that have become rare and may be in danger of disappearing. In the Midwest, the main focus of this interest is the tall grass prairie ecosystem (Ref. 98). Many of the areas that are being preserved are prairie remnants existing in abandoned pioneer graveyards and along railroad tracks. An alternative to preserving existing prairies is the establishment of prairie systems on lands that have been used for other purposes. The Weldon Spring site is an excellent example of land with such potential. Because of the increasing public awareness and interest in natural ecosystems,

both public relations and aesthetic benefits would be derived from the seeding of native prairie grasses on the site.

Plants typically used for land reclamation are introduced Eurasian cool-season grasses, such as improved varieties (cultivar) of fescue, bluegrass, timothy, and bromegrass. Cool-season grasses are those which initiate growth in the spring and become semidormant in the hot summer months (Ref. 97). Because they are more susceptible to damage during drought conditions, introduced grasses would be detrimentally affected by severe dry periods. The potential for soil erosion would be increased if the plants were harmed by drought. Furthermore, unless repaired, these damaged areas would be open to invasion by weedy, short-lived species. Once invaded, the damaged areas will take several years to stabilize themselves through the natural replacement of these weeds with more long-lived plants. The natural process of plant succession, from an unstable plant community with low diversity to a stable plant community with high diversity, could be significantly prolonged by planting non-native plants.

The prairie grasses proposed are native to this region of Missouri and have evolved to tolerate the wide range of climatic conditions. They will persist under environmental circumstances that cause less well-adapted introduced plants to die out (Ref. 97). Native grasses will create a stable ecosystem which will either maintain itself as prairie or will slowly change via the natural process of secondary plant succession into a similarly stable ecosystem comprised of more woody species. Hardwood forest or a mixture of hardwood forest and natural prairie swales may be the eventual final (climax) vegetation.

Technical Uncertainties

The use of native grasses for prairie restoration, wildlife habitat enhancement, plantings for erosion protection, and pasture and hay production has become an increasingly common and popular practice throughout the Midwest in the past decade. The Missouri Department of Conservation (MDOC) and the Soil Conservation Service are proponents of their use (Ref. 97, Ref. 99, Ref. 100, Ref. 101, and Ref. 102).

Successful planting techniques are well established, and seeds are available from several sources. Cool, spring burns on prairie plantings are an important tool in ensuring their success. Techniques for conducting these light scorchings are also well established, and they pose little or no danger to surrounding areas when properly executed. Air quality issues can be an

important consideration when planning maintenance scorchings. Proper timing, agency notification, and public relations all play an important role.

Design Criteria and Specifications

The criteria and specifications for this task have been defined and discussed in more detail than other tasks, because the information was readily available. However, the information presented is still considered conceptual and is subject to change during Title II design. The proposed conceptual specifications are listed below:

- All seed sources will meet state certification requirements established by the State of Missouri for cleanliness, viability, and purity.

- Tolerances for all mulch materials will be established, based on State of Missouri mulching standards and specifications and will be tested to ensure these tolerances are met.

- Mulching or use of a temporary cover crop is essential to establish stands. These and all related techniques will meet state specifications and guidelines.

- Fertilizer and agricultural limestone, if used, will meet state specifications.

- Criteria for seedling survival rates will be established and surveillance will be conducted following seeding to verify that the survival rate is within those standards.

- The effectiveness of seedbed preparation and planting techniques and equipment will be stated and verified before use.

- Approved pesticides or herbicides, if used, will be applied by licensed applicators in a manner consistent with State and Federal law.

- Soil tests, per Soil Conservation Service guidelines, will be conducted whenever a new soil or soil condition presents itself, to ensure that adequate and appropriate soil amendments are introduced. For example, tests will be conducted whenever a new, in-place soil is encountered, whenever a soil from a new outside borrow source is

used, or whenever subsurface soils are used. Soil tests will be conducted in a manner sufficient to regulate and change the fertility of each soil to meet the growth requirements of the intended seeded species.

- In areas that are to be mowed, mowing dates and plant height shall take into consideration the physiological needs of the plants. No mowing should be performed after August 1 or before April, and mowing height should be no closer than 4 in.

5.4.4.2 **Site Security.** Site closure also includes the security of the site as part of the final site conditions. The function of the site security system is to protect the public. One of the primary features of site security is the installation of a security fence around the cell. Several factors were evaluated to determine the benefits and consequences of constructing a security fence. No other alternatives have been identified for evaluation. No DOE or other regulatory criteria have been identified that relate to the placement of a security barrier around a disposal cell during post-closure.

This study recommends the use of a chain-link fence that lasts at least 30 years. The chain-link fence is recommended based on logic and the evaluation of the following major factor:

- Protection of the cell cover from intruders. Due to the proximity of the site to local residences, many hunters, off-road vehicles, firewood cutters, and curious persons, among others, frequent the area. The site could receive a substantial amount of traffic during the first few years.

Functional Requirements

The fence is intended to limit unauthorized public access to the cell area including the monitoring wells, leachate collection basin, and any other monitoring stations. Authorized personnel and vehicle access will be through a locked access control gate. The fence may be located along the outside perimeter of the buffer zone with the access control gate located between the administration building and the new access control building. The fence will require special treatment at major drainages to ensure proper flow.

It is recommended that signs warning intruders to keep out be placed on the fence at approximately 100-ft intervals. An appropriate sign should also be placed at the highway

entrance. The final site layout for the cell for the CSS alternative is presented in Figure 5.4-2 and for the VIT option in Figure. 5.4-3 .

Performance Requirements

The design life of the fence should be at least 30 years. The fence should be chain-link and meet DOE security fence criteria of a minimum of 6 ft high with a 1 ft barbed top guard.

5.4.5 Groundwater Monitoring Wells

Groundwater monitoring points need to be established in the vicinity of the disposal cell to monitor the performance of the cell (including the leachate collection system) and to detect any release of contamination after site closure. The monitoring and sampling points or monitoring locations may include wells, springs, and seeps. Some existing monitoring locations will remain, but new monitoring locations need to be added during the site closure activities. This report does not address in detail the current groundwater conditions, or future decisions regarding the need for groundwater restoration in the vicinity of the cell. These subjects will be evaluated and discussed under the independent groundwater operable unit. The types of monitoring points are discussed and detailed in draft *Supporting Study 4B, Disposal Facility Hydrological Performance Monitoring* (in progress) Ref. 103). Only the results of this study will be mentioned in this report. *Supporting Study 4B* concluded that vadose zone monitoring was not practical at the site, and therefore, it is not discussed in the *Technical Information Document*.

The requirements for monitoring points pertain to location, specifications, and design criteria for groundwater monitoring wells. Performance requirements for springs used as monitoring locations pertain to surveyed descriptions of each location which include standard coordinates and elevation. A reference monument denoting the station number should be placed at each location to ensure data consistency. The information provided in this study is based on the general hydraulic characteristics of aquifers, site hydrogeology, and the procedures followed during previous site investigations. The proposed designs and recommendations are conceptual and may be changed prior to or during final design. The presentation of specific monitoring well locations, depths, screened intervals, and other relevant features in a conceptual study is not practical, particularly before the results of the groundwater operable unit study are available.

Reliable long-term monitoring of the aquifer systems beneath the Weldon Spring site can be accomplished by incorporating carefully developed criteria for the location, depth, and other technical specifications into the design approach for groundwater monitoring wells. Detailed design criteria are listed and discussed, and conceptual locations and designs for monitoring wells are presented in the following sections. These criteria are intended to comply with all applicable Federal, State, and local regulations.

Types of Monitoring Stations

The different types of monitoring points evaluated in *Supporting Study 4B* (Ref. 103) include:

- Monitoring wells.
- Monitoring springs and surface water.
- Structural access (galleries, portals).
- Nonintrusive techniques.

Evaluation, Selection, and Discussion of Preferred Alternatives

Alternatives were evaluated in an MVE session for *Supporting Study 4B*; a brief summary is presented in MVE Table 5.4-7. This table lists the evaluation criteria and the advantages and disadvantages of each alternative. The preferred alternatives are installing monitoring wells and sampling of springs and surface waters. The principal advantages of monitoring wells are that wells can be placed at various locations around the cell with relative ease (use of a drilling rig), can provide the capability of monitoring various horizons in the subsurface, are widely used at hazardous waste sites as a method of monitoring and sampling, and are reasonably successful for detecting contamination in the groundwater before it reaches the point of compliance (POC). The actual location of the POC for the site has not been determined; it will be selected during the groundwater operable unit study or during Title II final engineering design. The POC is defined in 40 CFR 264.95 as a "vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units."

MVE Table 5.4-8 lists the potential design deviations associated with each of the preferred alternatives and the effect on design. The deviation with the highest probability of

occurring is that of locating wells that would encounter a fractured rock network in the subsurface with directional permeabilities which would preferentially control the groundwater flow patterns. If these fractures are not encountered, it may limit the efficacy of a groundwater monitoring system. Packer tests performed during well drilling may indicate the presence of such fractures, but it is unlikely that all preferential flow paths in a fractured system could be detected. The data needs for groundwater monitoring are listed in MVE Table 5.4-9. This table identifies specific questions, deviations, and data collection activities that need to be addressed prior to or during final design.

Figure 5.4-4 shows the potentiometric surface of the shallow groundwater aquifer at the Weldon Spring site. This figure shows that groundwater flow under the cell footprint is oriented toward the northwest; a minor flow component from the southeastern portion of the cell flows toward the north and northeast. Given these flow directions, groundwater monitoring wells should be located in the northwest, north, and northeast to intercept and monitor groundwater that flows under the cell footprint. Monitoring wells in the shallow aquifer may then function to detect and possibly remove or contain contaminated groundwater. The following topics should be considered when designing the groundwater monitoring system for the disposal cell:

- Location.
- Monitoring well design.
- Selection of chemical parameters for sampling.
- Sampling frequency.
- Hydrostratigraphy.
- Locations of preferential flow paths.
- Vertical and horizontal hydraulic gradients.

Location of Groundwater Monitoring Points

The locations of existing groundwater monitoring wells in the vicinity of the disposal cell, which may be used for post-closure monitoring, are shown on Figure 5.4-5. Existing wells that are not incorporated into the disposal cell groundwater monitoring system, or do not serve other as yet undefined purposes relating to the groundwater operable unit or environmental monitoring, should be properly abandoned. Conceptual locations for proposed monitoring wells are based on a preliminary review of the potentiometric surface in the aquifer and the spacing of the existing wells.

The proposed locations for post-closure monitoring wells are presented in Figures 5.4-6 and 5.4-7. Figure 5.4-7 shows the locations of existing wells that may remain for post-closure monitoring purposes. The distribution of these wells is in the northwest, north, and northeast areas of the site. Additional wells should be drilled in the vicinity of the disposal cell to provide better coverage. These wells are depicted in Figure 5.4-7. The number of wells tentatively selected encircle the cell at intervals of approximately 500 ft. This distance between wells may change, depending on the results of the groundwater modeling study and the identification of preferential flow paths in the subsurface. The specific locations of wells around the disposal cell may be changed prior to Title II design, but a conceptual scenario is presented in this report. Based on preliminary analysis of the flow paths presented in Figure 5.4-6, monitoring wells may be spaced closer than 50 ft intervals in the northwestern and southeastern fenced areas of the cell and approximately 500 ft in the remaining perimeter. The combination of monitoring wells located inside and outside the cell perimeter fence and selected area springs would provide a practical monitoring network that is correlated with the groundwater flow beneath the cell. The configuration of the disposal cell groundwater monitoring well system has been conceptualized for discussion purposes at this stage of design. Optimization of the disposal cell groundwater monitoring system configuration will be accomplished through studies performed to support the groundwater operable unit and/or Title II design. The following criteria will be used to optimize the disposal cell groundwater monitoring system:

- Disposal cell location. The ultimate location of the disposal cell will influence the layout of the monitoring system.

- Hydraulic gradient and flow direction. The direction of groundwater flow is in response to the hydraulic gradient and should be considered when locating monitoring points. Groundwater in the unconfined shallow bedrock aquifer flows from a regional topographic high located beneath the site to the west. Groundwater flow beneath the site closely reflects the effects of a regional surface water divide that is coincident with an east trending ridge. Groundwater flow in the northern portion of the site is to the north and groundwater flow in the southern part of the site is to the south.

- Aquifer transmissivity and hydraulic conductivity. Indicated orientations of maximum transmissivity, as determined by pumping tests, should be considered when selecting the location of monitoring points. Zones or layers of relatively higher

hydraulic conductivity as determined by packer tests, slug tests, and pumping tests may indicate a preferred direction of contaminant movement and desirable locations for monitoring points.

- Results of tracer tests. Subsurface pathways defined by dye tracer tests and seepage runs should be considered when locating monitoring points.

- Bedrock surface topography. Maps and cross sections showing elevation contours of the top of weathered and unweathered limestone may indicate preferred pathways for contaminant migration.

- Structural features and bedrock jointing. The results of joint mapping in bedrock outcrops, trends of linear segments of stream channels, linear surface depressions, fracture counts and descriptions in bedrock core, and other data used to determine predominant joint orientations should be considered when locating monitoring points.

- Solution cavities and bedrock weathering. The locations of boreholes where circulation loss occurred during drilling and where solution features, core loss, and bedrock weathering were described in drill logs should be considered when locating monitoring points.

- Direction of contaminant plume migration. The direction of potential contaminant movement should be considered when locating monitoring points.

- Concentration of contaminants in groundwater. The concentration of contaminants at a particular location generally dictates whether recovery or control is necessary.

- Contaminant velocity and mobility. The rate of movement and the potential for migration of contaminants should be considered when locating monitoring and control wells.

- Presence of multiple hydrostratigraphic unit zones. The results of hydrogeologic investigations show the presence of multiple hydrostratigraphic units beneath the Weldon Spring site. Individual hydrostratigraphic units contain distinct properties, including direction of groundwater movement, hydraulic gradient, degree of

weathering, and hydraulic conductivity. Separate well location maps for each hydrostratigraphic unit should be developed to properly assess the adequacy of monitoring systems. Groundwater monitoring systems should be developed for the:

- Saturated overburden.
- The weathered zone of the shallow bedrock aquifer.
- The unweathered zone of the shallow bedrock aquifer.

- Well abandonment. The location and depth of wells scheduled for abandonment (to allow for remediation and closure activities) should be evaluated and considered when planning for new groundwater monitoring points. Existing wells that are not depicted in Figure 5.4-6 will be abandoned. It is also conceivable that some existing wells, which will remain for post-closure monitoring, will be replaced.

- Existing well locations. The locations of wells that will remain after abandonment for remediation and closure activities should be reviewed and compared to the above criteria to determine usefulness for long-term monitoring. The condition and construction details of existing wells should also be considered.

- Locations of springs and seeps. The need to monitor groundwater discharge from perennial springs and seeps in the vicinity of the disposal cell should be evaluated. Attention should be given to springs and seeps that are connected to subsurface pathways of contaminant migration, as demonstrated by the results of previous chemical analyses, or by dye tracer tests.

- Recommendations in supporting studies. Recommendations in other technical reports and studies for locations of groundwater monitoring points should be incorporated into the final evaluation.

- Future studies. Additional studies should be conducted based on a refined conceptual model of site hydrogeology to close existing data gaps and optimize the design of the final disposal cell groundwater monitoring system.

Monitoring Well Design Criteria

Monitoring well design will be determined during the final design stages. This section presents the general design criteria that may be adopted during Title II. This conceptual design is presented and discussed in the following subsection under "Typical Monitoring Well Construction." The following criteria have been developed to assist in determining monitoring well design:

- Depth to groundwater. The depth to groundwater impacts the setting of the well screen in water table aquifers. For monitoring wells designed to monitor the flow at the phreatic surface, the top of the screen should be above the seasonal high water table to allow free entry of groundwater or free floating contaminants (if present) during this period.

- Magnitude of seasonal fluctuations in potentiometric surface. The magnitude of seasonal fluctuations in the potentiometric surface should be evaluated to determine the proper screen length.

- Aquifer thickness. The thickness of an aquifer or water bearing zone impacts the length of well screen selected for the monitoring well. It should be noted that screen lengths greater than 20 ft may dilute the sample. If the saturated thickness of the zone to be monitored is greater than 20 ft, it may be desirable to complete nested wells or multiport samplers at various depths within the aquifer.

- Presence of multiple hydrostratigraphic units. The results of hydrogeologic investigations show the presence of multiple hydrostratigraphic units beneath the site. Distinct design features may be required to effectively monitor groundwater within the principal hydrostratigraphic units present in the shallow groundwater system. Well designs should be developed for:

  - Groundwater in the saturated overburden principally the residuum.
  - Groundwater in the weathered zone of the shall bedrock aquifer.
  - Groundwater in the unweathered zone of the shallow bedrock aquifer.

- Physical/chemical properties of groundwater contaminants. The physical and chemical properties of groundwater contaminants should be assessed to select proper materials (casing, screen, bentonite, and grout) for wells designed for long-term monitoring.

- Chemical properties of natural groundwater. Well construction materials that are compatible with the natural groundwater chemistry should be selected for long-term monitoring.

- Design specifications of existing monitoring wells. The design features of existing wells should be reviewed before new wells are drilled. If the design specifications are appropriate, new wells should be constructed in a similar fashion to ensure data consistency.

- Recommendations in supporting studies. Recommendations in other technical reports and studies should be incorporated into the final monitoring well design specifications.

Typical Monitoring Well Construction

New monitoring wells drilled and installed at the Weldon Spring site will incorporate appropriate design features following evaluation of the above criteria. Typical monitoring well construction details are shown in Figure 5.4-8. The procedures for monitoring well design and installation are found in draft procedure ENG 16.18s, *Geotechnical Procedure for Monitoring Well Design and Installation*.

Selection of Chemical Parameters for Analysis of Groundwater Samples

A series of criteria have been developed for the selection of parameters for analyzing groundwater samples from monitoring wells, springs, and seeps. The chemical parameters should be established using the extensive database developed from the results of previous sampling efforts at the site. In addition, it would be prudent practice to determine background levels by establishing a well head inventory of contaminants and probable sources prior to implementing the monitoring program. Because the Weldon Spring site borders U.S. Army property, coordination with the Army may be required during the preparation of the monitoring

and sampling plan to address any remedial action and groundwater program the Army may have. The following topics should be considered in establishing criteria for identifying the contaminants of concern:

- Chemicals used in former explosives production facility and uranium feed materials processing plant.
- Existing water and soil chemical data base.
- Review of contaminants of concern at site.
- Regulatory standards which may be determined to be appropriate as indicator parameters for evaluating disposal cell performance.
- Results of supporting studies.

Tracers or indicator parameters such as conductivity, pH calcuim, and radium, while not contaminants, may provide early warning for leachate migration from the cell and should be considered for inclusion in the routine monitoring plan. Table 5.4-10 presents some of the contaminants listed in the *Feasibility Study* (Ref. 1) that may be sampled in the groundwater; other contaminants may be included at a later date. The final list of contaminants to be analyzed will be defined during Title II design.

Sampling Frequency of Groundwater Monitoring Points

The sampling frequency at groundwater monitoring points will most likely follow the requirements stated in the post-closure plan. The current concept is that sampling will be performed semiannually for at least 30 years following closure; however, a quarterly sampling program could be implemented for the first five years, followed by semiannual, and possibly annual, sampling. The chemical parameters should be established using the extensive database developed from results of previous site sampling and analysis programs and may include those parameters listed in Table 5.4-10. The following criteria should be considered in determining the sampling frequency for monitoring wells, springs, and seeps:

- Magnitude of fluctuations in detected chemical concentrations.
- Size of and reliability of established database.
- Rate of contaminant transport in the subsurface.
- Regulatory requirements.
- Recommendations in supporting studies.

5.4.6 Surface Runoff Controls

The objectives of surface runoff controls are to minimize erosional effects within the site and to reduce the potential for adverse effects downstream offsite. Pertinent details regarding site runoff are presented in Section 5.1.6. Final grading is discussed in *Supporting Study 16 - Grading Plan* (Ref. 50). This section addresses only briefly the natural runoff controls such as minimizing grades, use of swales, and vegetation. The *Surface Water Management Plan* (Ref. 36) will be adhered to during these activities.

Functional Requirements

The objectives of surface water runoff controls are to minimize erosional effects on the post-closure phase and to allow the site to return to a natural state. Most surface runoff control structures placed during cell construction activities will be removed. The new runoff control structures are discussed in Section 5.1.6.

Performance Requirements

Runoff from the cell and the immediate surrounding area will generally flow away from the cell. The surface water drainage in the vicinity of the site is shown in Figure 5.4-9. Figure 5.4-10 illustrates the current surface runoff drainage plan at the site. Natural slopes on the site range from about 1.0% to about 12.5%. The surface water drainage divide between the Mississippi and Missouri rivers passes through the Weldon Spring site near the southern boundary. The drainage on the north side flows to the Mississippi River, and the drainage on the south flows into the Missouri River.

Rainfall amounts for various durations and return periods are:

Storm Duration	Return Period (Inches) 2-Years	10-Years	25-Years	100-Years	PMP
6 hours	2.45	3.57	4.52	5.66	31.2
24 hours	3.28	4.76	6.02	8.21	36.4

(Ref. 47)

No alternatives for site closure runoff controls have been identified. The surface water control plan, however, should consider at least the following four control measures, each addressing surface runoff controls:

- Grading slopes.
- Ditches and swales.
- Riprap protection.
- Vegetation.

All excavated holes will be backfilled in accordance with a final grading plan and the site graded to drain away from the disposal cell. Final grading of slopes should be maintained at 1.0% minimum to minimize ponding and 12.5% maximum to prevent scouring and erosion. An analysis should be performed during final design, based on maximum storm design criteria, to determine optimum grades. Sheet flows should not exceed 500 ft in length without appropriate design and computations.

Channels, ditches, and swales may consist of parabolic, vee, or trapezoidal shapes and shall be designed for 100-year precipitation as the normal design period. The dimensions of waterways will be based upon minimum capacities, grades, soil types, vegetation, maximum permissible velocities, and use of riprap. Waterways with flow velocities 4 fps or less will be lined with grass, and those with flow velocities greater than 4 fps will be lined with riprap. Channels, ditches, and swales should be maintained by removing sediment build up, repairing and stabilizing eroded areas, mowing overgrown grasses, and removing brush or debris that has collected.

The use of culverts is discouraged; however, if used, these culverts should be designed using the Rational Method for a 10-year storm without any static head and a 100-year storm

using available head and considering backflow effects. Riprap shall be designed to resist displacement by moving water. Design shall consider the following:

- Weight, size, shape, and gradation of stones.
- Depth of water flowing over the stones.
- Slope of the surface under the riprap.
- Stability and effectiveness of material under the riprap.
- Velocity of flowing water against the stones.
- Protection of toe or terminus edge of the riprap.
- Durability requirements.

The following design criteria, drawings and specifications are specific to surface water runoff controls and should be considered for final design:

- Design Criteria

  - Site grading and topsoil criteria.
  - Vegetative stabilization methods.
  - Design storm events and return periods.
  - Channel, diversion, ditch, and swale design parameters.
  - Sediment basins and retention ponds.
  - Culvert sizing and placement.
  - Riprap design procedures.

- Drawings

  - Final site grading and drainage plan.
  - Final channel and ditch plan and capacities.
  - Channel and ditch sections and details.
  - Sediment basin and retention pond plans, sections, and details.
  - Culvert plans, sections, and details.

- Specifications

  - Earthwork.
  - Site grading and topsoil.
  - Vegetation: seeding and mulching.
  - Manufactured organic mulch matting.
  - Culverts.
  - Riprap and gabion.
  - Filter fabric.

5.4.7 General Design Criteria, Drawings, and Specifications

General site closure design criteria, drawings, and specifications are required for the site closure subcontract documents for the proposed final site conditions. Following is a listing of items that may be required; specific items related to site closure activities have been included in previous sections.

- General Design Criteria

  - Proposal for Engineering Services.
  - Deliverables and schedules.
  - Engineering cost estimate.
  - Organization and staffing.
  - Design Basis Memorandum.
  - Scope and description of site closure work.
  - Statutory compliance.
  - Site closure criteria.
  - General removal and remedial criteria.
  - Security measures.
  - Material handling and transporting.
  - Permanent and temporary vegetation.
  - Monitoring well design.
  - Permanent and temporary drainage control measures.
  - Site closure schedule.
  - Engineering criteria.

- General Drawings

  - Cover sheet.
  - Index of drawings and general notes.
  - Existing site plan prior to closure.
  - Permanent and temporary security fencing.
  - Final site topography and drainage plan.
  - Final site road plan.
  - Final vegetation plan.
  - Monitoring well design.
  - Post-closure site plot plan.

- General Specifications

  - General provisions.
  - General conditions.
  - Health and safety plan.
  - Summary of work.
  - Measurement and payment.
  - Quality assurance and quality control.
  - Construction surveying.
  - Temporary facilities.
  - Temporary utilities.
  - Dust control.
  - Material handling and transporting.
  - Earthwork.
  - Finish grading and preparation.
  - Riprap.
  - Fencing.
  - Site closure.

5.4.8 Site Closure System Analysis

The site closure system analysis addresses the interaction of site closure activities with other CDR studies. Interaction with other CDR task activities is limited, however, because most

of the remediation work should be near completion when the site closure activities commence. The only interactions may be during the removal of contaminated materials from the support facilities and the dirty roads and the placement of this material in the cell before it is closed. There appears to be no conflict with the performance of the site closure system analysis, particularly if this work is conducted as part of the waste excavation, transportation, and disposal activities. Once the last of the contaminated dirty road material is disposed of, the cell can be closed and completed, and the site closure activities dealing only with clean materials can be executed.

The site closure components that require evaluation from a systems analysis perspective include:

- Removal of support facilities (clean material only).
- Removal of existing roads and construction of permanent clean roads.
- Installation of monitoring wells.
- Review and implementation of final surface runoff controls (not considered in the site drainage study, Section 5.1.6).
- Establishment of final site security (fence, access control, and signs).
- Revegetation of the Weldon Spring site.

The specific operations related to the performance of each of these components will be discussed in Section 6.4. The site closure design aspects described in this section present no conflicts or problems. The sequence of the activities, however, is the topic of systems analysis. The currently proposed sequence of site closure activities is described below.

1. Identify contaminated materials that need to be placed in the disposal cell. These may include buildings and structures from the waste treatment plant, foundations from the TSA and decontamination pads, and dirty roads.

2. Remove contaminated materials starting with the areas the farthest from the remaining open cell area in order to maximize the use of dirty roads. The dirty road leading to the disposal cell should be one of the last features removed. One of the decontamination pads should also remain for decontaminating equipment used to handle contaminated materials. This pad may be removed before closing the cell. Temporary mobile decontamination equipment may be used to clean any remaining equipment.

3. Remove remaining structures to allow for backfilling and site grading. Identify a location for the temporary storage of demolished material that may be used for road construction. The CMSA may be a suitable site since it is a clean location. Remove or abandon the existing monitoring wells that will not be used for post-closure monitoring.

4. Allow for completion of the grading plan. Construction of the cell perimeter road commences. The construction material stored in the CMSA is removed, and the CMSA area is graded.

5. Begin construction of final site drainage structures after the site has been graded to reflect final conditions. Coordinate this activity with construction of the cell perimeter road. Site drainage and final grading are related activities and the systems analysis study should reflect this interrelationship. The site closure study refers only to the final runoff control structures. These structures are discussed in Section 5.1.6.

6. Survey, drill, and install the monitoring wells.

7. Establish site security. Install the fence around the cell, construct the access control point, place signs, and install any other security components.

8. Establish a final site survey.

The sequence proposed in this conceptual study represents only one feasible implementation scenario. This sequence may be modified as subcontracts are issued for work.

5.5 Long-Term Monitoring and Maintenance

5.5.1 General

Long-term (post-closure) monitoring and maintenance activities for the site must comply with potential action-specific ARARs compiled for this operable unit. Contaminant-specific, post-closure ARARs may be defined at a later date when more information on the waste becomes available. The regulatory requirements for post-closure monitoring and maintenance were researched for five basic types of disposal facilities: RCRA hazardous waste landfills, UMTRA cells, EPA/Nuclear Regulatory Commission (NRC) mixed and waste cells, sanitary landfills, and TSCA polychlorinated biphenyl (PCB) landfills. Potential requirements that are applicable or relevant and appropriate for the site were identified. These ARARs were then further refined to develop a site-specific post-closure monitoring and maintenance strategy.

The proposed post-closure ARARs will be implemented through adherence to the site-specific post-closure plan developed for the site. Though the preparation of such a post-closure plan is not mandatory under the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) (under which the site operates), the plan will provide for documentation, guidance, and quality control required for the various monitoring and maintenance activities. Because all the activities related to post-closure monitoring and maintenance will reflect compliance with the site ARARs, it is important that these requirements be correctly developed and approved prior to the development of the post-closure plan. The selection of site specific monitoring components or the detailing of site-specific maintenance activities at this time would not be logical or cost-effective because the site post-closure ARARs proposed in the *Conceptual Design Report* (CDR) have not been approved by the DOE nor have they been submitted to the State of Missouri and the EPA for review. However, once these proposed ARARs are finalized, reviewed, and approved, the preparation of the post-closure plan can proceed. The approved ARARs will be used to formulate the design basis for the development of the site post-closure maintenance and monitoring plan. The preparation of this plan may require the listing and evaluation of alternative schedules, frequencies, and the types of proposed site inspections, groundwater monitoring methods, custodial maintenance and repair, and contingency response operations. These topics are briefly described in Section 5.5.3. Specific components and requirements of the post-closure monitoring and maintenance plan are subsequently described as these conform with the ARARs proposed for the site. The plan will

be further developed during Title II final design work and as the *Record of Decision* (ROD) (Ref. 3) is finalized.

5.5.2 Proposed ARARs (Preferred Alternative)

The site falls under the CERCLA and this requires the site to comply with applicable or relevant and appropriate requirements. Following an evaluation of the various post-closure requirements and their appropriateness to Weldon Spring site-specific conditions, the long-term monitoring and maintenance study results determined that the site post-closure plan should comply with the ARARs for RCRA and UMTRA type cells, with some variations. The criteria used to select the proposed ARARs are the long-term protection of human health and the environment through post-closure maintenance and monitoring at the site applicable requirements promulgated under Federal or State law that specifically address the long-term monitoring and maintenance at the site, and relevant and appropriate requirements that address a situation similar to that of the site. The proposed alternative was developed from a combination of existing ARARs for two types of disposal facilities and leans more toward requirements for a RCRA-type cell. The proposed ARARs for the site post-closure monitoring and maintenance are listed in MVE Table 5.5-1.

5.5.3 Details of Preferred Alternative

Adherence with the first requirement for post-closure monitoring at the site involves the preparation of a post-closure monitoring and maintenance plan. This plan will incorporate the design and operational requirements so as to provide written, clear, and concise descriptions of the long-term activities required at the site. This includes a description of the possible actions to be taken in emergency situations, upkeep of records, inspection procedures, and other matters related to monitoring and maintenance at the site. The topics to include in this plan are:

- Legal and regulatory requirements
- Site location
- Site access
- Responsible parties
- Final site conditions
- Site inspections
- Environmental monitoring

- Custodial maintenance
- Corrective actions
- Emergency measures
- Quality assurance
- Reporting and record keeping requirements
- Personnel health and safety

These topics are listed and described in the document *Draft General Guidance for Long-Term Surveillance and Maintenance of Off-Site DOE Radioactive Waste Disposal Sites*, (Ref. 105). Table 5.5-2 is obtained from the aforementioned document and lists the main subtopics that need to be addressed; the leachate collection and removal system was added for the site. This table will be modified to accommodate the specific-site conditions at the site, but Table 5.5-2 provides general guidelines in the preparation of the post-closure plan.

This plan will address the actions of the four basic maintenance and monitoring tasks. These tasks respond to the post-closure requirements proposed for the Weldon Spring site. The tasks are:

- Routine site inspections
- Groundwater monitoring
- Custodial maintenance and repair
- Contingency response

The sequence of the decision making process applicable to these tasks is clearly described in the document *Guidance for Surveillance and Monitoring for the UMTRA Project - Long-Term Care Program*, (Ref. 106). A modified version of this process applicable to the Weldon Spring site is presented in Figures 5.5-1 through 5.5-6. A brief explanation of the four basic post-closure tasks follows.

5.5.3.1 Routine Site Inspections. These inspections will be required to monitor the facility yearly or semiannually, as determined in the monitoring plan. A checklist should be prepared to facilitate these inspections, and a site inspection map should be drafted following each inspection. The guidance document mentioned above contains an example of an inspection checklist that can serve as a guidance checklist for the site. Such a checklist would also form

part of the post-closure plan. Site inspections should be carried out semiannually for a period of 30 years.

5.5.3.2 Groundwater Monitoring. The groundwater monitoring program will comply with the applicable requirements of 40 CFR 264.90 *et seq*. Topics to be resolved during the preparation of the monitoring plan include the identification of the constituents to sample and the establishment of concentration limits for each constituent including background, ion concentrations maximum concentration limits (MCL) and alternate concentration limits (ACL); the definition and description of the POC; the number, location, and depth of wells including wells for determining background detection levels; sampling and analysis procedures; and contingencies for detection, compliance, and corrective action monitoring programs.

5.5.3.3 Custodial Maintenance and Repair. The activities to be covered in this task include all those required to maintain the integrity and effectiveness of the final cover, the leachate collection and removal system, the surveyed benchmarks, and the overall maintenance of the site. Probable sources and effects of erosion and degradation mechanisms (chemical, physical, and hydraulic) on the site disposal facility need to be identified. These may be included in the inspection checklist for the site.

Tables 5.5-3 through 5.5-6 present some of the degradation mechanisms and parameters to consider for various structures and facility components at the site. The tables were obtained from the document, *Low-Level Radioactive Waste Disposal Facility Closure - Part II* (Ref. 107) and modified for the site. Some of the information in these documents is germane to the Weldon Spring site.

Post-closure site inspections and maintenance operations should be conducted semiannually. Under the RCRA, groundwater sampling activities must be performed at least semiannually (40 CFR 264.98[d]) and it would appear prudent and cost-effective to plan the post-closure site inspections, maintenance, and groundwater sampling activities together. It is also recommended that the land use, climate, and plant and animal community structure be reevaluated every 10 years to assess the impact any changes may have on the site. Examples of site conditions that may require custodial maintenance or repair include the following:

- Grass mowing (for the vegetated slopes or other areas). This activity may be performed semiannually at the start and end of summer.

- Weed and vegetation control (for the rock slopes) performed semiannually.
- Access road maintenance. This can be performed during semiannual site inspections and maintenance operations.
- Drainage ways (clear obstructions and repair), performed semiannually.
- Animal control (livestock, burrows on the cell), performed as needed.
- Repairs to monitoring wells, fences, gates, and other site structures. This can be performed, as needed, or during the semiannual site inspections.
- Filling of rills and gullies.

5.5.3.4 **Contingency Response.** Contingency response needs to be incorporated in any monitoring program to address the possibility that the site integrity has been or will be compromised. Contingency inspections may precede the response; these are unscheduled inspections warranted by reports of vandalism, unauthorized intrusion, an extreme natural event, or other such causes. These contingency measures are outside the planned, regular inspections for the site. Reporting requirements will need to be described and included in this section of the monitoring plan.

5.5.4 Technical Uncertainties

A list and description of the technical uncertainties will be developed once the long-term monitoring and maintenance plan is prepared and the monitoring activities are detailed.

5.5.5 Operational Requirements

The operational requirements of the post-closure monitoring activities will be described for each component of the monitoring and maintenance plan only after the ARARs proposed in the CDR are approved and the post-closure plan is subsequently prepared. The plan will require planning, agreement among the various parties as to its contents, and an adequate response to the proposed site requirements. This effort is comprehensive and will require a number of

supporting studies to evaluate site specific information to streamline the plan and meet the basic criterion of protection of human health and the environment and subsequent acceptance by the public and various agencies.