FINAL
DESIGN CRITERIA PACKAGE
ON-SITE DISPOSAL FACILITY REVISION OF OSDF PHASE V PROJECT NUMBER 20105

United States Department of Energy
Fernald Environmental Management Project
Fernald, Ohio

prepared by

GEOSYNTEC CONSULTANTS

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under

Fluor Fernald, Inc.
Contract No. 03FF0699
Document No. 20105-DC-0001

REVISION 1
JANUARY 2004

REVISED FINAL DESIGN CRITERIA PACKAGE ON-SITE DISPOSAL FACILITY

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REVISION SUMMARY

Revision	Dated	Description of Revision
0	5/13/1997	Initial issuance of Revision 0, *Design Criteria Package, On-Site Disposal Facility.*
1E	01/31/2002	Issuance of Revision 1E to update information, incorporate design criteria for the enhanced permanent leachate transmission system, and include safety criteria.
1F	10/27/2003	Issuance of Revision 1F to incorporate Regulatory comments on Revision 1E.
1	01/15/2004	Issuance with Regulatory Comments on Revision 1E incorporated.

ACRONYM LIST

ACI	American Concrete Institute
ALARA	As Low As Reasonably Achievable
ALR	Action Leakage Rate
ANSI	American National Standards Index
ARAR	Applicable or Relevant and Appropriate Requirement
AASHTO	American Association of State Highway and Transportation Officials
ASCE	American Society of Civil Engineers
ASTM	American Society of Testing and Materials
AWWT	Advanced Wastewater Treatment
CAD	Computer-Aided Design
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	Certified for Construction
CFR	Code of Federal Regulations
CSI	Construction Specifications Institute
CQA	Construction Quality Assurance
CQC	Construction Quality Control
DCP	Design Criteria Package
DOE	United States Department of Energy
DSIWM	Department of Solid and Industrial Waste Management
E&S	Erosion and Sediment
EPLTS	Enhanced Permanent Leachate Transmission System
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Corporation
FS	Feasibility Study
GCL	Geosynthetic Clay Liner
LCS	Leachate Collection System
LDS	Leak Detection System
EPLTS	Leachate Transmission System
NRC	Nuclear Regulatory Commission
NEC	National Electrical Code
OAC	Ohio Administrative Code
ODOT	Ohio Department of Transportation
OEPA	Ohio Environmental Protection Agency
OMTA	OSDF Material Transfer Areas
OSDF	On-Site Disposal Facility
OU1	Operable Unit 1
OU2	Operable Unit 2

ACRONYM LIST

OU3	Operable Unit 3
OU4	Operable Unit 4
OU5	Operable Unit 5
RA	Remedial Action
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RI	Remedial Investigation
ROD	Record of Decision
SCS	Soil Conservation Service
SDR	Standard Dimension Ratio
SDRI	Sealed Double-Ring Infiltrometer
UMTRA	Uranium Mill Tailings Remedial Action
USDA	United States Department of Agriculture
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
USOSHA	United States Occupational Safety and Health Administration
WAC	Waste Acceptance Criteria

DCP GLOSSARY

Applicable or Relevant and Appropriate Requirements (ARARs)	Requirements set forth in regulations that implement environmental and public health laws must be attained or exceeded by a selected remedy unless a waiver is invoked. ARARs are divided into three categories: chemical-specific, location-specific, and action-specific, depending on whether the requirement is triggered by the presence or emission of a chemical, by a vulnerable or protected location, or by a particular action.
Aquifer	A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield economical quantities of water to wells and springs.
Battery Limit	The designated boundary of construction activities for specific contracts. The battery limit defines the area for which the contractor is responsible for operations related to the contract to include any temporary erosion and sediment control features required to assure discharge permits are not violated.
Chemical Compatibility	A material is defined as being compatible with a chemical, or with a suite of chemicals such as in a leachate, if its physical and mechanical properties are not changed or adversely affected by prolonged exposure to the chemical or suite of chemicals.
Factor of Safety	A measure of the degree of stability of an earthen (soil or rock) slope or foundation. Mathematically, it is defined as the factor by which the shear strength of the material along a potential slip surface through the slope or foundation must be divided to bring the slope or foundation to a state of barely stable equilibrium (i.e., incipient failure).
Feasibility Study (FS)	The study that fully evaluates and develops remedial action alternatives to prevent or mitigate the migration or release of hazardous substances, pollutants, contaminants, or hazardous constituents at and from the site. The FS is generally performed in conjunction with the remedial investigation (RI) and uses data gathered during the RI to develop remedial action alternatives and to undertake an initial screening and detailed analysis of the alternatives. The RI data are used to define the objectives of the response action, to develop remedial action alternatives, and to undertake an initial screening and detailed analysis of the alternatives. The FS includes a report that describes remedial action

DCP GLOSSARY

alternatives and that documents the selection process.

FEMP	The Fernald Environmental Management Project, the present name (beginning August 23, 1991) for the former Feed Materials Production Center near Fernald, Ohio.
Geotextile	Any permeable textile used with foundation, soil, rock, earth, or any other geotechnical or environmental engineering material as an integral part of a project, structure, or system.
Geomembrane	An essentially impermeable membrane used with foundation, soil, rock, earth, or any other geotechnical or environmental engineering material as an integral part of a project, structure, or system.
Geonet	A 3-dimensional netlike polymeric material used for in-plane drainage with foundation, soil, rock, earth, or any other geotechnical or environmental engineering material as an integral part of a project, structure, or system.
Great Miami Aquifer	Glaciofluvial sand and gravel deposited by the meltwaters of Pleistocene glaciers within the entrenched ancestral Ohio and Miami rivers. This is also termed a buried channel or sand and gravel aquifer.
Ground Water	Water in a saturated zone or stratum beneath the surface of land.
Hydraulic Conductivity	A parameter that describes the rate at which water can move through a porous medium. This parameter may vary with the direction of the flow.
Impacted Surface-Water Runoff	Liquid that comes in contact with impacted material and runs off the material rather than percolating.

DCP GLOSSARY

Impacted Material — This term refers to that material at the FEMP meeting OSDF waste acceptance criteria (WAC) as defined in the operable unit Records of Decision (RODs).

Leachate — Liquid that has percolated through, or been released from, solid waste. In the case of the OSDF, this refers to liquid that has percolated through, or been released from, the impacted material that has been disposed in the facility.

Operable Unit — A discrete action that comprises an incremental step toward a comprehensive site-wide remediation. This discrete portion of a remedial response is intended to eliminate or mitigate a release, threat of a release, or pathway of exposure. The cleanup of a site can be divided into a number of operable units, depending on the complexity of the problems associated with the site. Operable units may address geographical portions of a site, specific site problems, or initial phases of an action, or may consist of any set of actions performed over time or any actions that are concurrent but located in different parts of a site.

Perched Ground Water — Perched ground water exists in geologic environments where a low permeability clay overlies a more permeable sand which leads to the formation of an unsaturated zone both above and below a saturated zone within the clay.

Remedial Investigation (RI) — The investigation conducted to fully evaluate the nature and extent of the release or threat of release of hazardous substances, pollutants, contaminants, or hazardous constituents. The RI emphasizes data collection and site characterization. The RI, which includes sampling and monitoring, as necessary, also includes the gathering of sufficient information to support the feasibility studies and the risk assessments.

Select Impacted Material — Soil-like impacted material with a maximum particle size of 6 in. and with 80 percent of the particles finer than 1 in. which is placed both on top of the protective layer and beneath the contouring layer to provide a physical barrier between debris and other "large-size" impacted material and the OSDF liner and final cover systems.

DCP GLOSSARY

Shear Strength — A parameter widely used in engineering analyses of the stability of soil slopes and foundations. It is defined as the shear force required to cause a unit area of material to fail in shear.

Surface Water — All water that is open to the atmosphere and subject to surface runoff

Till — A mixture of boulders, cobbles, sand, silt, and clay deposited directly from glacial ice; generally of low permeability.

Undisturbed — An adjective used to describe a soil sample obtained in a manner that results in minimal disturbance to the soil's structure and strength-deformation characteristics. It is important to obtain "undisturbed" samples of a soil slope or foundation if it is necessary to evaluate the strength, compressibility, or permeability of that slope or foundation.

Water Table — The surface of an unconfined aquifer at which the pressure in the water is equal to the atmospheric pressure. This usually occurs at or near the top of the saturated subsurface material.

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1. GENERAL DESCRIPTION

1.1 Purpose and Organization

1.1.1 Purpose

This Design Criteria Package (DCP) identifies Comprehensive Environmental Restoration, Compensation and Liability Act (CERCLA) applicable or relevant and appropriate requirements (ARARs), U.S. Department of Energy (DOE) functional requirements, and general design criteria that will be used as the basis for design of the Fernald Environmental Management Project (FEMP) On-Site Disposal Facility (OSDF). This DCP is intended to be compliant with all pertinent safety requirements of United States Occupational Safety and Health Administration (USOSHA) and FEMP. Specific requirements are found throughout the DCP for pertinent safety criteria related to the various design elements. However, the controlling document for safety issues is the Environmental Health and Safety/Training Requirement, Area 3A/4A Excavation OSDF Project [Fluor Fernald, 2001].

The conceptual design for a FEMP OSDF was developed as an alternative in the Operable Unit 2 (OU2) feasibility study (FS) and identified as the selected remedial alternative in the OU2 Record of Decision (ROD) [DOE, 1995c]. On-site disposal of impacted material is also the preferred alternative for Operable Unit 3 and Operable Unit 5 at the FEMP. In addition, the material sent to the OSDF by OU3 may include contributions from OU1 and OU4. All material destined for OSDF disposal must meet the OSDF waste acceptance criteria (WAC). The OU2 ROD has established an initial WAC for the OSDF of 346 picoCuries/gram (pCi/g) of uranium-238 (U-238) or 1030 parts per million (ppm) total uranium.

DOE intends to build only one on-site disposal facility. Therefore, the OSDF will be designed to accommodate all or any portion of the total volume of impacted material meeting the WAC that results from remediation of the FEMP operable units. The total volume of such material from these operable units is estimated to be 2.5 million cubic yards bank/unbulked.

The construction, filling, and closure of the OSDF is scheduled to occur over a period of approximately 7 years, as described in the Accelerated Remediation Plan

[$276 million case]. However, due to the potential for variations in funding (which would lead to variations in the pace of remedial action activities), the OSDF must be designed to be constructed, filled, and closed in phases for up to 25 years, with the possibility of closure on an interim basis should it be required. In the context of this DCP, any interim closure of the OSDF is understood to be to the same standards and configurations as final closure.

The design approach for the OSDF, as well as the other portions of the operable unit selected remedy, are presented in the document, "*Final Remedial Design Work Plan for Remedial Actions at Operable Unit 2*" [DOE, 1995d]. The design will be implemented in the following three phases:

- *Phase 1:* design of an impacted material haul road from the south field and inactive and active fly ash pile areas to the OSDF:
- *Phase 2:* design of the OSDF; and
- *Phase 3:* design of the excavation and restoration of the waste unit areas.

This DCP addresses design activities associated with Phase 2 of the *Final Remedial Design Work Plan for Remedial Actions at Operable Unit 2*. The DCP provides criteria for the design of each element of the OSDF that is located within the OSDF battery limit. The elements in the OSDF battery limit include the OSDF structure, leachate management system, soil liner test pads, perimeter drainage structures, roads, berms, temporary and permanent surface-water management and erosion control features, and temporary construction features such as soil stockpile areas, OSDF Materials Transfer Areas (OMTA), equipment wash facility, and other features. Other design packages consistent with the integrated approach to FEMP remediation will be prepared for features of the OSDF that are to be located beyond the battery limit, such as the forcemain from the leachate transmission lift station manhole to the biosurge lagoon. "Design interfaces" exist for those locations where a design component crosses the battery limit.

1.1.2 Organization

This DCP is organized as follows:

- The remainder of Section 1 presents additional information on the project scope and design.
- In Section 2, specific design criteria for each component of the OSDF are presented.
- In Section 3, the design deliverables are identified and brief descriptions of the contents of the deliverables are described.

1.2 Project Scope

1.2.1 Introduction

The purpose of this section of the DCP is to briefly describe the major design steps for the OSDF elements described in Section 1.1 above. These steps include, but are not limited to: finalization of this DCP; preparation of preliminary (30%), optional intermediate (60%), prefinal (90%), and final (100%) design packages; preparation of a certified-for-construction (CFC) package; development and implementation of a soil liner test pad program; development and implementation of a geomembrane liner compatibility study; and interface activities.

1.2.2 Design Steps

The major design steps for the OSDF project are summarized below.

- *Preparation of Design Criteria Package.* This DCP identifies the criteria that will be used to design the OSDF.
- *Development and Implementation of Soil Liner Test Pad Program.* The soil liner test pad program will be used to evaluate the performance of candidate materials and construction methods for the clay components of the liner and final cover systems of the OSDF.

- *Development and Implementation of Geomembrane Liner Compatibility Study.* The geomembrane liner compatibility study will be used to evaluate the durability characteristics of the geomembrane materials that will be used in the liner and final cover systems of the OSDF.

- *Preparation of Preliminary Design Package.* The preliminary design package will be prepared in a manner that addresses the design criteria identified in this DCP and that illustrates the concepts of the design for review by DOE, USEPA, and OEPA.

- *Preparation of Intermediate Design Package.* The intermediate design package will contain the same elements as the preliminary design package, plus: (i) revisions based on USEPA, and OEPA comments on the preliminary design; (ii) revisions based on the results of the value engineering session; and (iii) notes added to the preliminary design drawings that are necessary to describe the proposed plan for construction of the OSDF.

- *Preparation of Prefinal Design Package.* The prefinal design package will contain the same elements as the intermediate design package, plus: (i) revisions based on DOE, USEPA, and OEPA comments on the detailed design; (ii) all drawings and calculations essentially complete; and (iii) prefinal design construction cost estimate.

- *Preparation of Final Design Package.* The final design package will include the elements of the prefinal design package, plus: (i) revisions based on DOE, USEPA, and OEPA comments on the prefinal design; and (ii) final design cost estimate.

- *Preparation of CFC Design Package.* The CFC design package will include the elements of the final design package as well as revisions to the drawings based on comments on the final design package, engineer's certification of the drawings, and certified specifications that are suitable for construction purposes.

- *Design Change Notice (DCN).* Design changes that are authorized following issue of the CFC design package will be implemented through an approved FEMP DCN procedure. The procedure will include coordination of design changes on-site at the FEMP and approval of the DCN by the design organization.

- *Phased CFC Design Packages.* Construction of the OSDF will be performed in phases. Each construction phase, including an Enhanced Permanent Leachate Transmission System (EPLTS), will be designed consistent with this DCP, the OSDF CFC Package, and lessons learned during construction in prior phases (if any). The preparation of these Phased CFC Design Packages is anticipated to include preliminary, prefinal, and final CFC Packages.

- *Preparation of Work Plans.* A number of OSDF-specific work plans will be prepared as part of the OSDF design effort. These work plans, coupled with the OSDF drawings and specifications, will dictate actions related to the OSDF that will be undertaken during the OU2 remedial action (RA).

- *Revision of Support Plans.* Support plans and this DCP should be revised from lessons learned from construction, design changes, and improved design approaches. The approval process for revisions to the support plans and this DCP will be similar to the approval process for the original document.

- *Interface Activities.* Interfaces between the design of the OSDF and other design activities at the FEMP are described in Section 1.4 of this DCP.

1.2.3 Schedule for Design and Support Activities

The schedule for design of the OSDF is presented in the *Final Remedial Design Work Plan for Remedial Actions at Operable Unit 2* [DOE, 1995d]. The amended consent agreement milestones and dates for the OSDF given in this DCP are as follows:

- submit OSDF Preliminary Design Package to USEPA: 22 December 1995;

- submit OSDF Prefinal Design Package to USEPA: 28 June 1996;

- submit OSDF Final Design Package/CFC to USEPA: 14 October 1996;

- submit Draft OSDF Remedial Action Work Plan to USEPA: 12 April 1996; and

- submit Final OSDF Remedial Action Work Plan to USEPA: 28 June 1996.

1.3 Major Components of the OSDF

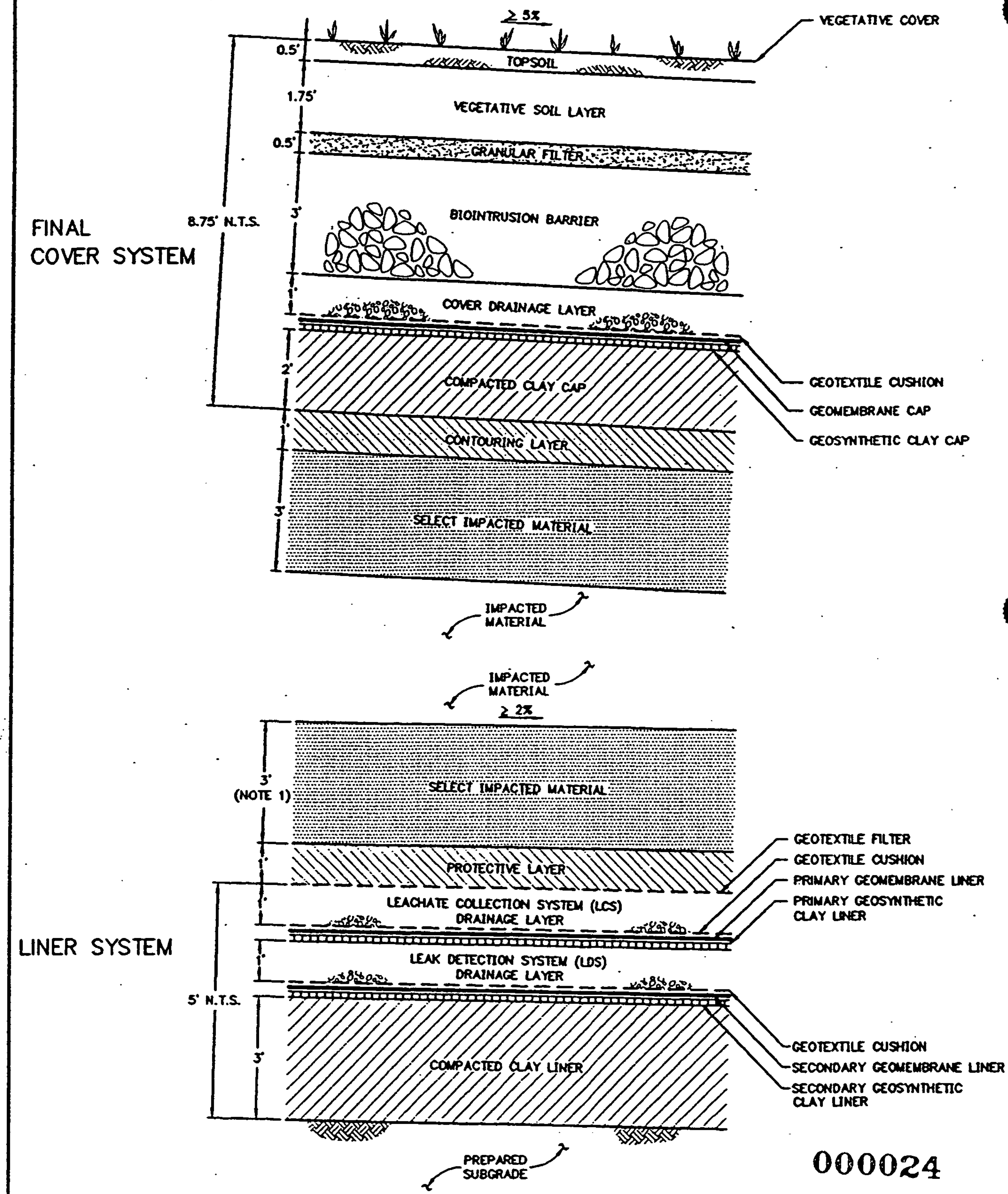
The major components of the OSDF, as identified in the *Detailed Facility Description/Functional Requirements* (presented in Appendix B of this document), are the liner system, final cover system, leachate management system, surface-water management system, support elements, utilities, and temporary support facilities.

- *Liner and Final Cover Systems.* The liner and final cover systems will be constructed using both soil and geosynthetic components. The conceptual design of the liner and final cover systems are presented in Appendix B. The preliminary designs for these systems, as currently developed, are shown in Figure 1-1. As shown in this figure, the liner system will consist of a double-composite liner that will have a leachate collection system (LCS) above the primary liner and a leak detection system (LDS) between the primary and secondary liners. The final cover system will include a composite cap overlain by the following layers: drainage layer; biointrusion barrier; granular filter layer; vegetative soil layer; and topsoil. The liner system and final cover system designs will be prepared considering material borrow requirements, seasonal (i.e., winter) closure, and site preparation requirements.

- *Leachate Management System.* The leachate management system will be designed to collect leachate generated by the OSDF and convey it to the biosurge lagoon. Major components of the leachate management system within the battery limit will include: double-walled gravity drain pipes from each OSDF cell, EPLTS valve house for each cell, LDS and LCS collection tanks and associated piping and valving within the valve house, permanent double-walled gravity transmission pipe, control valve house, permanent lift station, and a till monitoring system.

- *Surface-Water Management System.* The surface-water management system will be designed to manage surface water under both short-term (i.e., during construction and impacted material placement) and long-term (i.e., after OSDF closure) conditions. The design will address surface-water runon and runoff, perched ground water, construction water, and wastewater from various sources such as the equipment wash facility.

LINER AND COVER SYSTEM DESIGN
ON-SITE DISPOSAL FACILTY



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NOTE:

1. SELECT IMPACTED MATERIAL THICKNESS ABOVE LINER SYSTEM MAY BE DECREASED TO 2 FEET IF THE FIRST LIFT OF MATERIAL TO BE PLACED OVER THE SELECT IMPACTED MATERIAL CONSISTS OF SOIL OR RELATIVELY SMALL SIZE DEBRIS THAT CAN BE PLACED IN CONTROLLED LIFTS.

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FIGURE NO.	1–1
PROJECT NO.	GE3900–16.4
DOCUMENT NO.	F9650002.CDO
FILE NO.	F95C001.DWG

- *Support Elements and Utilities.* Both permanent and temporary support elements will be designed for the OSDF. Permanent support elements include survey benchmarks and a leachate transmission system access corridor. Temporary support elements may include security fencing, an administrative support area, equipment wash facility, one or more OMTAs, construction materials staging areas, and construction haul roads. Required utilities may include electrical, water, and wastewater for the administrative support area, and water and power for other specified areas.

1.4 Design Interfaces

There are a number of issues and activities at the FEMP site that will be impacted by the design, construction, filling, and closure of the OSDF. The identified design interfaces are:

- the capacity and treatment capability of the advanced wastewater treatment (AWWT) facility, the capacity of the biosurge lagoon, and the piping tie-in by forcemain from the OSDF permanent lift station to the biosurge lagoon;
- tie-in of required new utilities at the battery limit, including:
  - power;
  - water;
  - security system wiring;
  - wastewater; and
  - telephone;
- relocation of existing utilities within the battery limit;
- design and construction of the haul roads, equipment wash facility, and leachate transmission system access corridor, and relocation and/or removal of a section of the north entrance road;

- remediation of the FEMP operable units and coordination of traffic from the operable units and staging areas within the former production facility to the OSDF;
- environmental, safety and health, and other training requirements during OSDF construction, filling, and closure;
- landscape design for the OSDF;
- stakeholder communication and input;
- security issues; and
- certification activities.

1.5 Sources of Information

1.5.1 Information Categories

Information from a variety of sources should be used to design the OSDF. These sources include:

- project documents prepared as part of the CERCLA remediation process now underway at the FEMP; ARARs in these documents are particularly relevant to the design of the OSDF;
- DOE/USEPA/USOSHA/OEPA orders, standards, and guidance;
- FEMP site-specific pre-design investigations and studies;
- standard building codes such as the National Electric Code, National Fire Prevention Code, and the Uniform Building Code; and
- general technical literature.

1.5.2 CERCLA-Related Documents

The CERCLA-related documents relevant to design of the OSDF are:

- Final Remedial Investigation Report for Operable Unit 2 [DOE, 1995a];
- Final Feasibility Study Report for Operable Unit 2 [DOE, 1995b];
- Final Record of Decision for Remedial Actions at Operable Unit 2 [DOE, 1995c];
- Final Remedial Design Work Plan for Remedial Actions at Operable Unit 2 [DOE, 1995d];
- Final Feasibility Study Report for Operable Unit 5 [DOE, 1995e]; and
- Draft Record of Decision for Remedial Actions at Operable Unit 5 [DOE, 1995f].

Select portions of the *Final Record of Decision for Remedial Actions at Operable Unit 2* are included in Appendix A of this document. The OU2 Record of Decision also contains the ARARs for OU2. These ARARs are presented in Appendix C. The ARARs for OU5, which are contained in the *Draft Record of Decision for Remedial Actions at Operable Unit 5*, are presented in Appendix D.

1.5.3 DOE/USEPA/USOSHA/OEPA Orders/Standards/Guidance

The primary DOE, USEPA, USOSHA, and OEPA orders, standards, and guidance relevant to the design of the OSDF are:

- Uranium Mill Tailings Remedial Approach Document, Revision II [DOE, 1989];
- Project Management System [DOE, 1992];
- Natural Phenomena Hazards Mitigation [DOE, 1993];

- Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities [DOE, 1994];
- Requirements for Hazardous Waste Landfill Design, Construction, and Closure [USEPA, 1989];
- Guidance on EPA Oversight of Remedial Designs and Remedial Actions Performed by Potentially Responsible Parties [USEPA, 1990];
- Design and Construction of RCRA/CERCLA Final Covers [USEPA, 1991];
- RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities [USEPA, 1995]; and
- Ohio EPA Division of Solid and Infectious Waste Guidance, Interpretations, and Communications [various dates].
- DOE Technical Standards List [DOE, 1999]
- DOE Handbook – Design Considerations [DOE, 1999]
- USOSHA, 29 CFR Parts 1910 and 1926
- Fluor Daniel Fernald Safety Performance Standards, RM-0021

1.5.4 Site-Specific Design Documents

The primary site-specific predesign studies and investigations are:

- "*Predesign Investigation and Site Selection Report for the On-Site Disposal Facility*" [DOE, 1995g]. This report contains data and information on subsurface conditions within the portion of the FEMP property (east of the former production area) having favorable hydrogeology for siting the OSDF.
- "*100- and 500-Year Flood Plain Determination Sitewide*" [Parsons, 1993]. This report establishes the floodplain boundaries of Paddys Run within the FEMP property as a result of the 100- and 500-year rainfall events.

- "*On-Site Disposal Cell Pre-Design Activities Engineering Report*" [Parson, 1994]. This report presents results of a subsurface investigation in the currently-proposed area at the southeast corner of the FEMP property that will be developed for soil borrow to be used in OSDF (which, at the time of the report, was a candidate location for the OSDF).

- "*2,000-Year Flood and Probable Maximum Flood Sitewide Flood Plain Determination*" [Parsons, 1995a]. This report establishes the 2,000-year and probable maximum precipitation events and the corresponding sitewide floodplain boundaries.

- "*Geotechnical Investigation Report, On-Site Disposal Facility*" [Parsons, 1995b]. This report contains geotechnical data for the subsurface soils in the OSDF area, including data compiled from previous investigations performed at the FEMP.

- "*Disposal Facility Pre-Design Geotechnical Investigation, Soil Investigation Data Report, CERCLA/RCRA Unit 2*" [Science Applications International, Corporation, 1995]. This report presents geotechnical data for the subsurface soils in the OSDF area. The report contains data that is subsequently summarized and presented by Parsons [1995b].

- "*Geotechnical Data and Evaluation Report for East and South Field Borrow Areas*" [Parsons, 1996a]. This report contains geotechnical data for the subsurface soils in the East Field borrow area. This borrow area will be developed as part of the OSDF project.

- "*Off-Site Borrow Materials Evaluation*" [Parsons, 1996b]. This report presents geotechnical data for potential off-site borrow sources for OSDF construction materials, including fine and coarse concrete aggregates, pea gravel, and riprap.

1.5.5 Standard Building Codes

The primary standard codes used in the design of the OSDF will be the version in effect at the time of the specific design deliverable as listed below:

- American Institute of Steel Construction (AISC) Standards, AISC 5335, Specification for Structural Steel Building;
- American Iron and Steel Institute (AISI) Standards, AISI 5G-673, Design of Cold-Formed Steel Part II Structural Members, Cold-Formed Design Manual;
- American Society of Civil Engineers (ASCE) Standards, ASCE 7, Minimum Design Loads for Buildings and Other Structures;
- American Welding Society, Inc. (AWS) Standards, AWS D1.1, Structural Welding Code;
- Building Officials and Code Administration International (BOCA), Ohio Basic Building Code (OBBC);
- International Conference of Building Officials (ICBO) Uniform Building Code (UBC);
- Metal Building Manufacturer's Association (MBMA) Low-Rise Building Systems Manual (MBMA Low-Rise Building Systems Manual);
- National Electric Safety Code (NESC), C2-93 by Institute of Electrical and Electronic Engineers (IEEE);
- National Electric Code (NEC), NFPA 70-96 by National Fire Protection Association (NFPA);
- American Concrete Institute Building Code, ACI 318 by American Concrete Institute (ACI);
- UL Standard for Safety Grounding and Bonding Equipment, UL 467-93 by Underwriters Laboratories, Inc. (UL); and
- Building Services Piping, ASME B31.9 by American Society of Mechanical Engineers (ASME).

1.5.6 General Technical Information

In addition to the project-specific information described above, a significant body of general technical information (e.g., textbooks, technical manuals, computer software) will be used in preparation of the OSDF design. This information is referenced where cited throughout this DCP.

1.6 Project Deliverables

The design of the OSDF will be documented in the project deliverables, including calculations, drawings, specifications, and reports. The DCP identifies the contents of these deliverables and establishes the criteria to be considered in preparing each deliverable. Lists of anticipated CFC calculations, drawings, and specifications are presented in Tables 1-1, 1-2, and 1-3, respectively. It is noted that drawings and specifications that primarily present construction details and contractor instructions need not be included in the design package submittals (preliminary, intermediate, prefinal, and final) for regulatory review.

Reports that will be prepared as part of the design process for the OSDF and which are addressed by this DCP are:

- design criteria package (DCP);
- preliminary, intermediate, prefinal, final, and CFC design packages to include: drawings, technical specifications, and calculations;
- geomembrane liner compatibility study work plan and report;
- soil liner test pad work plan and report;
- soil-geosynthetic interface testing work plan and report;
- construction quality assurance (CQA) plan;
- impacted material placement plan;
- impacted material quality assurance plan;

- surface-water management and erosion control plan;
- borrow area management and restoration plan;
- systems plan;
- environmental air monitoring plan;
- ground-water monitoring plan;
- OSDF construction cost estimate;
- value engineering documentation;
- design documentation; and
- responses to DOE, OEPA, and USEPA comments on project deliverables.

Additional discussion of the required project deliverables is given in Section 3 of this DCP.

1.7 Revision of this DCP

Compilation, review, and acceptance of this DCP initially precedes preparation of the other design deliverables. As design and review proceed, better approaches, details, etc. are identified. As a result, this DCP is modified with each design package to reflect these revisions. This DCP is a controlled document.

TABLE 1-1
LIST OF ANTICIPATED CALCULATIONS
On-Site Disposal Facility
Fernald Environmental Management Project

1. INTRODUCTION
   - 1.1 Design Parameter Summary
   - 1.2 Computer Program Validation
   - 1.3 Select Technical References
   - 1.4 Geotechnical Data Points

2. OSDF LAYOUT
   - 2.1 Required Volume
   - 2.2 Capacity Verification
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ENHANCED PERMANENT LEACHATE TRANSMISSION SYSTEM CALCULATIONS

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Fernald Environmental Management Project

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On-Site Disposal Facility
Fernald Environmental Management Project

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Section 02230	Road Construction
Section 02240	Protective and Contouring Layers
Section 02250	Vegetative Soil Layer
Section 02270	Erosion and Sediment Control
Section 02271	Riprap
Section 02280	Biointrusion Barrier
Section 02605	HDPE Manholes, Pipe, and Fittings
Section 02710	Granular Drainage Layer
Section 02712	Granular Filter
Section 02714	Geotextiles
Section 02721	Culverts
Section 02770	Geomembrane Liner and Cap
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Section 02831	Chain Link Fence and Gates
Section 2920	Topsoil
Section 02930	Vegetation

DIVISION 3: CONCRETE

Section 03100	Concrete

DIVISION 13: SPECIAL CONSTRUCTION

Section 13000	Borrow Area Management
Section 13005	Liner Penetration Boxes
Section 13010	Impacted Material Placement
Section 13020	Construction Phase Leachate Management
Section 13030	Seasonal Closure
Section 13040	Control of Fugitive Emissions

DIVISION 15: MECHANICAL

Section 15000	Mechanical

DIVISION 16: ELECTRICAL

Section 16000	Electrical
Section 16100	Basic Materials
Section 16110	Raceways
Section 16120	Conductors and Terminations
Section 16130	Outlet, Junctions, and Pull Boxes
Section 16400	Overhead Services
Section 16450	Grounding
Section 16500	Lighting

ENHANCED PERMANENT LEACHATE TRANSMISSION SYSTEM

DIVISION 2: SITE WORK

Section 02050	Demolition
Section 02100	Surveying
Section 02110	Clearing, Grubbing, and Stripping
Section 02200	Earthwork
Section 02215	Trenching and Backfilling
Section 02230	Road and Parking Areas Restoration
Section 02270	Erosion and Sediment Control
Section 02271	Riprap
Section 02605	High Density Polyethylene (HDPE) Pipes and Fittings
Section 02714	Geotextiles
Section 02721	Culverts
Section 02930	Vegetation

DIVISION 3: CONCRETE

Section 03100	Concrete
Section 03110	Concrete Protective Liner

DIVISION 8:

Section 08110	Standard Steel Doors and Frames

DIVISION 9:

Section 09900	Painting

DIVISION 10:

Section 10211	Metal Wall Louvers

DIVISION 13: SPECIAL CONSTRUCTION

Section 13120	Pre-Engineered Buildings

1.8 Documentation of Compliance with DCP

Documentation must be prepared to demonstrate that all OSDF design criteria contained in this DCP are satisfied. This documentation should be prepared after completion and submittal of the final design.

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2. DESIGN CRITERIA

2.1 OSDF Location

2.1.1 General Design Criteria

The general design criteria for the location of the OSDF are as follows (design considerations).

- The location should result in safe construction (to include impacted material placement) and long-term performance of the OSDF.
- The location should result in protection of human health and the environment and cost-effective development of the OSDF.
- The location should comply with ARARs.
- The location should minimize interference with remediation and decommissioning activities in the former production area.

The OSDF should be located entirely within the FEMP property in the area of most favorable hydrogeology (functional requirement). The general area identified as such is located east of the former production area, is rectangular in shape, and has approximate dimensions of 800 ft by 4,300 ft. This area is shown in Figure 1 of Appendix B.

2.1.2 Specific Location Criteria

The OU2 ARARs (Appendix C) provide siting criteria for the OSDF derived primarily from the Ohio Administrative Code (OAC) 3745-27-07(H). These criteria require that the disposal facility not be located within the following areas:

- within 300 ft of the property boundary to the limit of waste placement ((H)(4)(b));
- within 1,000 ft of an existing domicile, existing water supply well, or developed spring ((H)(4)(c) and (H)(3)(c));
- within 200 ft of a stream, lake, or natural wetland ((H)(4)(d));

- within 15 ft of the elevation of the uppermost aquifer ((H)(2)(e));
- within a regulatory floodplain;
- within the surface and subsurface areas surrounding a public water supply well through which contaminants may move toward and reach the public water supply well within a period of 5 years ((H)(3)(a));
- within a national park or recreation area, candidate area for potential inclusion in the national park system, state park or established state park purchase area, or, any property that lies within the boundaries of a national park or recreation area, but that has not been acquired or is not administered by the Secretary of the United States Department of the Interior ((H)(1)(a)-(d));
- in a sand or gravel pit where the sand or gravel deposit has not been completely removed ((H)(2)(a));
- within a limestone quarry or sandstone quarry ((H)(2)(b)); and
- within an area of potential subsidence due to an underground mine ((H)(3)(b)).

It is noted that DOE has obtained a CERCLA waiver for two location-specific ARARs based on an equivalent standard of performance [40 CFR §300.430(f)(1)(ii)(C)(4)]. The two location-specific ARARs for which a waiver has been obtained require that a disposal facility not be located:

- above an aquifer declared by the federal government under the Safe Drinking Water Act to be a sole source aquifer ((H)(2)(c)); and
- above an unconsolidated aquifer capable of sustaining a yield of 100 gallons/minute (6.3 liter/second) for a 24-hour period to an existing or future water supply well located within 1,000 ft of the limits of waste placement ((H)(2)(d)).

The proposed OSDF location does not satisfy these criteria as it is underlain at depth by the Great Miami Aquifer (GMA). A discussion of the basis of the waiver for these two ARARs is contained in the "*Final Record of Decision for Remedial Actions at Operable Unit 2*" [DOE, 1995c]. This discussion indicates that the basis for an equivalent standard of performance is a combination of engineering controls and existing site hydrogeology. This hydrogeology includes at least a 12 ft thickness of gray till beneath the entire OSDF footprint. It is noted that the aforementioned CERCLA ARAR waiver applies only to the on-site disposal of OU2 impacted material. Separate waivers from the two subject ARARs will be required for OSDF disposal of impacted materials from other operable units [DOE, 1995c].

In addition to the OU2 ARARs cited above, the OU5 ARARs (Appendix D) require that a disposal facility not be located within 200 ft of a fault that has undergone displacement during the Holocene Epoch (ARAR: OAC 3745-27-20(C)(3)).

Other criteria that should be considered in locating the OSDF on the FEMP property are given below.

- The centerline of the relocated north entrance road should be offset approximately 150 ft from the property line on the eastern side of the site to: (i) provide clearance for the power transmission corridor; and (ii) optimize the civil site layout of the road. The OSDF (including any required access corridor, surface-water management structure, or other OSDF-related structure) should, to the extent possible, minimize interference with the ditch or shoulder of the relocated north access road (design consideration).
- The limit of the OSDF (including any required access corridor, surface-water management structure, or other OSDF-related structure) on the western side of the site should be located to provide sufficient area for impacted material removal traffic between this limit and the eastern fence line (northeast corner) of the FEMP former production area (design consideration).
- The OSDF should be sited such that any perimeter areas or surface-water management structures can be constructed around the OSDF and within the battery limit (design consideration).

2.2 OSDF Layout

2.2.1 General Design Criteria

The OSDF will be a new feature of the FEMP property and must resist degradation during its design life due to wind, precipitation, temperature, runoff, runon, erosion, and other natural influences. A primary design criterion is therefore to appropriately lay out the OSDF as a stable, geomorphologic landform resistant to the natural influences present in and around the FEMP property (design consideration).

In addition, the layout of the OSDF must be such that the features of the design (e.g., liner system, final cover system, drainage channel) function as an integrated unit that completely isolate impacted material from the surrounding environment and that result in a constructable, maintainable, and cost effective facility (design consideration).

Lastly, the OSDF should be laid out so that it can be progressively developed in phases, utilizing contiguous cells that can be constructed, filled, and closed on a flexible schedule consistent with the final schedule for remediation of the FEMP operable units. The design of the OSDF must be flexible to accommodate an active life ranging from 7 to 25 years (functional requirement).

2.2.2 Specific Layout Criteria

2.2.2.1 Horizontal Limits

- The length and width of the OSDF will result in a facility that satisfies the siting ARARs identified in Section 2.1 of this DCP (ARARs).

- The horizontal layout should be adequate to provide a disposal capacity sufficient for 2.5 million cubic yards bank/unbulked impacted material (functional requirement). The OSDF should provide sufficient capacity for anticipated bulking of impacted material as a result of excavation, transport, and placement. The OSDF should also provide sufficient capacity to accommodate seasonal (winter) cover soil, if required. The OSDF should be designed with a "contingency" disposal capacity to be used in the event that the volume of impacted material requiring disposal increases as a result of remediation-phase confirmatory sampling and to provide additional capacity for potential partial closure activities. The contingency disposal capacity should be in the range of 10 to 15 percent of the specified required disposal capacity (design consideration).

- For cost effectiveness, the OSDF should be regularly shaped, to the extent possible, with as few changes in geometry as possible and with smooth transitions between changes in geometry (design consideration).

2.2.2.2 Final Height and Slope Limits

- The maximum height of the OSDF from the top of the final cover system to existing grade (measured at the crest of the facility) should not exceed 70 ft (functional requirement) and the average maximum height along the crestline should not exceed about 65 ft (design consideration).

- The final cover system will be constructed at slopes between 5 and 25 percent (ARAR: OAC 3745-27-08(C)(15)(f)(ii)). The slopes should be flat enough to satisfy slope stability factor of safety criteria and erosion control criteria. Within these constraints, slopes should be as steep as possible to achieve a cost effective design (design consideration).

- The transitions between topslope and sideslope areas of the final cover system should be gradual to prevent erosion caused by transitional flow of surface-water runoff (design consideration).

2.2.2.3 Foundation Grade and Slope Limits

- The bottom of the OSDF (i.e., bottom of the liner system) will overlie at least 12 ft of undisturbed gray till (equivalent standard of performance requirement for CERCLA ARAR waiver).

- The distance between the bottom of the compacted clay component of the OSDF liner system and the GMA will not be less than 15 ft (ARAR: OAC 3745-27-08(H)(2)(e)). For purposes of compliance with this requirement, the top of the GMA is considered to be the historical high water level in that aquifer.

- The OSDF liner system should be founded in native brown till to the extent feasible. Construction of the liner system on fill should be minimized (functional requirement).

- The OSDF should be laid out such that the top of the protective layer for the liner system is at or near existing grade (functional requirement). However, based on geometric considerations, founding of the liner system below existing grade in the northern portion of the OSDF is permitted (design consideration).

- The compacted clay component of the liner system will be constructed with a slope of at least 2 percent (ARAR: OAC 3745-27-08(C)(1)(h)). Therefore, the foundation grades must be constructed with a slope of at least 2 percent (design consideration). It is interpreted that this slope requirement does not apply along the leachate collection corridor.

2.2.2.4 Perimeter Features

- The OSDF should be laid out having a perimeter surface-water management system (design consideration). Design criteria for this system are given in Section 2.8 of this DCP.

- The OSDF should be laid out having an access corridor to leachate management system valve houses and cleanouts (design consideration). Design criteria for this access corridor are given in Section 2.9 of this DCP.

2.2.3 Calculations

Calculations required to establish the location and layout of the OSDF are as follows:

- OSDF required volume;

- OSDF capacity verification; and

- OSDF earthwork required volume.

2.2.4 References

FEMP property data and information required to locate and layout the OSDF should be obtained from the references cited in Section 1.5 of this DCP.

2.3 OSDF Performance

2.3.1 Design Life

The function of the OSDF is to isolate impacted material from the environment throughout the facility design life (i.e., for 1,000 years, to the extent reasonable, and in any case for 200 years) (ARAR: 40 CFR §192.02(a)). The OSDF design should be developed to achieve this design life goal. Requirements to achieve the goal fall into five categories, defined as follows (design considerations):

- *internal hydrologic control* - provide a high level of leachate containment and collection capability to prevent OSDF-related impacts to ground water and surface water;

- *external hydrologic control* - provide resistance to hydrologic impacts, including infiltration through the final cover system and damage by surface-water runon or runoff;

- *geotechnical stability* - provide adequate OSDF slope stability factors of safety for conditions throughout construction, filling, and closure, and then through the post-closure period, including impacts associated with potential long recurrence-interval earthquake events;

- *resistance to erosion* - provide resistance to erosion of the OSDF soil layers to achieve minimal erosional impacts throughout the design life; and

- *resistance to biointrusion* - prevent intrusion by plant roots and burrowing animals.

The requirements described above should be achieved in the OSDF design in the manner indicated in Table 2-1. Also, the requirements should be achieved by (design considerations):

- using natural (i.e., geologic), durable construction materials wherever possible (e.g., clay liners, gravel drainage layers, etc.);

- using those commercially-available geosynthetic construction materials that demonstrate the best long-term durability characteristics (e.g., high density polyethylene geomembranes);

- providing synergistic (e.g., adjacent geomembrane, GCL, and compacted clay liner and final cover system components) and redundant (e.g., dual leachate collection system drain pipes) design components; and

- designing a final facility geometry that replicates natural geomorphologic landforms (e.g., gently rolling topography).

TABLE 2-1

FUNCTIONAL REQUIREMENT - DESIGN FEATURE MATRIX
ON-SITE DISPOSAL FACILITY

FUNCTIONAL REQUIREMENT				
Internal Hydrologic Control	**External Hydrologic Control**	**Geotechnical Stability**	**Resistance to Erosion**	**Resistance to Biointrusion**
• Liner and final cover systems completely encapsulate impacted material • Thick geomembrane liner (80 mil) and cap (60 mil) used to maximize service life • Geomembrane liner and cap present through at least the initial and intermediate periods • Compacted clay liner and cap remains functional through final period • Leachate collection system remains functional through at least the initial and intermediate periods • Geochemical attenuation provided by at least 3 ft of compacted clay liner, two geosynthetic clay liners (GCL), and at least 12 ft of in-situ native gray till	• Facility designed to prevent uplift under extreme perched water conditions • Site designed to prevent surface-water runon to the OSDF under 2,000-year storm event • Site designed to control and route surface-water runoff away from the OSDF under 2,000-year storm event • Facility signed or constructed out of 2,000-year floodplain • Low-permeability cover used to minimize infiltration into the OSDF	• OSDF located on stable glacial till foundation • OSDF slopes designed to be very stable • OSDF designed to be resistant to deformation under 2,400 year design seismic event • Impacted material placed and compacted in stable configuration • Construction materials selected to enhance stability (e.g., textured geomembrane)	• OSDF designed to be a stable geomorphologic landform • Final cover system designed to have smooth transitions between cover top slopes and side slopes • Final cover system corners designed to be rounded • Final cover system slopes designed to be gentle to limit runoff velocity • Final cover system designed to resist erosion under design storm conditions • Biointrusion barrier beneath final cover system blocks potential depth of erosion or gullying	• Biointrusion barrier designed to impede plant root and animal intrusion • Primarily above-ground facility facilitates visual monitoring and maintenance • Continuing maintenance through the initial period and through as much of the intermediate period as necessary • Access to site limited and institutional controls can be implemented if necessary

The design of OSDF should be considered within a temporal framework. Over the OSDF design life (up to 1,000 years), the properties of some of the materials of construction, particularly the geosynthetics, may change. In addition, over time, and in the absence of external inputs, the impacted material will cease to generate leachate. To describe the behavior of the OSDF over time, three primary periods of behavior may be defined.

- *Initial Period.* The initial period is defined as the period from initial construction until the end of the 30-year post-closure monitoring period described in the *Final Record of Decision for Remedial Actions at Operable Unit 2* [DOE, 1995c]. It is assumed that during this period steady-state hydraulic conditions are established wherein leachate ceases to be generated by the facility, or continues to be generated, but at a very slow rate. Throughout this initial period, all components of the OSDF are maintained in a fully-functional condition.

- *Intermediate Period.* The intermediate period is assumed to begin 30 years after final closure of the OSDF and to last for at least 200 years, and up to 1,000 years to the extent reasonably achievable. During this period, the critical geosynthetic components of the liner and final cover systems are fully functional. The leachate collection and detection systems are still capable of being maintained, should there be a need (i.e., should there be significant leachate flow requiring maintenance and monitoring). The final cover system and leachate management system are capable of being fully maintained.

- *Final Period.* The final period is defined as the period during which the performance of the OSDF has stabilized to its permanent state. The final period does not occur for at least 200 years, and possibly up to 1,000 years after final closure of the OSDF. During this period, natural earth components of the liner and final cover systems continue to be functional. It is conservatively assumed that during the final period, the critical geosynthetic components of the liner and final cover systems are no longer fully functional, and the leachate collection and leak detection systems are no longer maintained.

The OSDF design should be configured to allow decision makers at the time of the final period to select an appropriate final management strategy for the facility (design consideration). These strategies are predicated on the assumption that the compacted clay cap component of the final cover system remains fully functional during the final period, and, thus, the rate of leachate generation during that period is very low. Potential management strategies include:

- allowing any leachate generated by the OSDF (due to infiltration through the OSDF final cover system) to migrate through the earthen components of the liner system into the brown and gray till that will underlie the OSDF; in this case, the leachate collection system and leak detection system drain pipes from each cell will be sealed by grouting or other appropriate measures; based on the studies performed for the OU2 FS [DOE, 1995b] this final period management approach will provide continuing protection of the underlying GMA; and/or

- maintaining the leachate collection system and leak detection system outlets from the OSDF cells; liquid that flows out of the cells can be collected and transported off-site for treatment, or discharged to a natural treatment system, such as a wetland area established at or near the site.

The design criteria presented in this DCP are intended to meet the design life goals of the OSDF under the assumptions of the "behavior periods" identified above. The design documentation that will be prepared for the OSDF should demonstrate how the design criteria satisfy these performance requirements for each behavior period.

Table 2-1 illustrates in a preliminary way how, for each of the project functional requirements, this DCP establishes design features to create a facility that will provide for the required performance.

2.3.2 Geotechnical Stability and Settlement

2.3.2.1 Static Slope Stability

A. Criteria

Static slope stability analyses should be performed for the following conditions at a minimum (design considerations):

- OSDF foundation
    - interim impacted-material configuration

    - final OSDF configuration

- OSDF liner system
    - short-term (i.e., end-of-construction) liner system on side slope
- OSDF impacted-material configurations
    - interim impacted-material configuration
    - final impacted-material configuration
- OSDF intercell berm
    - short-term condition
- OSDF final cover system
    - short-term condition on final side slope
    - long-term condition on final side slope
- OSDF access corridor
    - short-term condition
    - long-term condition
- borrow area cut slopes
    - long-term condition

The degree of stability of a slope is reported in geotechnical engineering in terms of the slope stability factor of safety. The factor of safety of a slope is the factor by which the shear strength of the material along a potential slip surface through the slope must be divided to bring the slope to a state of barely stable equilibrium (i.e., incipient failure) [Duncan, 1992]. A factor of safety of at least 1.0 is required for a slope to be stable. The larger the factor of safety, the more stable the slope. Therefore, a slope with a factor of safety of 1.5 is more stable than a slope with a factor of safety of 1.2.

Minimum acceptable factors of safety for the above analysis conditions should be developed considering the criticality of the OSDF, the consequences of failure, and guidance provided by:

- UMTRA Technical Approach Document [DOE, 1989];
- NAVFAC Design Manual [U.S. Navy, 1971]; and
- Duncan [1992].

Minimum acceptable factors of safety for static slope stability conditions should be at least those from the UMTRA Technical Approach Document. Minimum acceptable factors of safety from that document are listed below.

Condition	Minimum Acceptable Factor for Safety
Stability during construction	1.3
End of construction stability	1.3
Long-term stability	1.5
Post-flood rapid drawdown condition	1.2

B. Calculations

For each condition defined in (A) of this section, the engineer should define the critical conditions for stability and perform an analysis to confirm that the calculated factors of safety for the critical conditions are larger than the minimum acceptable values. In performing the analyses, the engineer should follow guidance provided in Holtz and Kovacs [1981], Duncan et al. [1987], and Kulhawy and Mayne [1990], for example, in choosing between total-stress and effective-stress analysis approaches and in choosing between unconsolidated-undrained (UU), consolidated-undrained (CU), and consolidated-drained (CD) shear strength parameters. In establishing shear strength parameters for geosynthetic interfaces, the engineer should consider not only the above factors, but also the differences between peak and large-displacement shear strength values. Proven approaches should be used that are consistent with the requirements of DOE and USEPA standards and guidelines. Acceptable approaches are described below.

- *OSDF Foundation.* For the OSDF foundation stability condition, use two-dimensional limit equilibrium analysis methods; for example, use Bishop's simplified method [Bishop, 1955] for circular potential slip surfaces and Janbu's simplified method [Janbu, 1973], Spencer's method [Spencer, 1973], or the Morgenstern and Price [1965] method for noncircular potential slip surfaces. Use the computer program XSTABL [Sharma, 1991; 1992], UTEXAS3 [Wright, 1991], or other widely-accepted and validated program.

- *OSDF Liner System.* For the short-term liner system on side slope, use the two-dimensional limit equilibrium method of Giroud et al. [1995a], or other comparable method. If seepage forces are potentially significant, use the approach in Giroud et al. [1995b], or other suitable method.

- *OSDF Impacted-Material Configurations.* For interim and final impacted material configurations, use the techniques listed under OSDF foundations above.

- *Intercell Berm and Access Corridor.* For short-term and long-term analyses, use the methods listed above under OSDF foundation, or other suitable method.

- *OSDF Cover System.* For the final cover system, use the two-dimensional limit equilibrium methods of Giroud et al. [1995a,b] listed above under OSDF liner system, or other suitable method.

- *Borrow Area Cut Slopes.* For long-term analyses, use the methods listed above under OSDF foundation, or other suitable method.

2.3.2.2 Seismic Slope Stability

A. Criteria

A seismic hazard assessment and site response analysis should be performed to evaluate potential seismically-induced peak horizontal accelerations of the OSDF foundation, liner system, and final cover system. The seismic hazard assessment should be based on the conservative assumption that the OSDF will be a Performance Category 2 facility as defined in DOE Order 5480.28 [DOE, 1993]. The OSDF foundation, liner system, impacted materials, and final cover system should be designed to comply with the more stringent of the criteria and guidance given below (design consideration).

- DOE-STD-1020-94, "*Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*", [DOE, 1994]. This DOE standard requires that Performance Category 2 facilities be designed for a peak ground surface acceleration having an annual probability of occurrence of 1×10^{-3}.

- USEPA/600/R-95/051, "*RCRA Subtitle D (258) Design Seismic Design Guidance for Municipal Solid Waste Landfill Facilities*", [USEPA, 1995]. This USEPA guidance document requires that new municipal solid waste disposal facilities be designed to resist the peak bedrock acceleration of a seismic event having a probability of occurrence of no greater than 10 percent in 250 years. This seismic design criterion applies to "all containment structures, including liners, leachate collection systems, and surface-water control systems ..." (40 CFR §258).

The minimum peak ground surface acceleration at the FEMP satisfying the DOE-STD-1020-44 requirement is 0.13 g, where "g" is the gravitational acceleration at the surface of the earth (32.2 ft/s^2). This acceleration value is obtained from Table C-5a of the DOE-STD-1020-94. The peak bedrock acceleration at the FEMP site, according to USEPA/600/R-95/051, is 0.16 g.

The results of the site response analyses should be used in pseudo-static stability analyses to evaluate OSDF seismic stability, and, if necessary based on the criterion given below, seismic deformation analyses should be performed (design considerations). The maximum permanent seismic deformation for all analysis conditions should be no larger than 6 in. based on the recommendations in Seed and Bonaparte [1992] and Anderson and Kavazanjian [1995].

B. Calculations

Seismic Hazard Assessment

A seismic hazard assessment should be performed for the OSDF. The purpose of the seismic hazard assessment is to associate an earthquake magnitude with the peak ground acceleration (PGA) values specified by [DOE, 1994] and [USEPA, 1995] and to select representative design accelerogram(s). The seismic hazard assessment should be performed in accordance with established earthquake engineering procedures.

Site Response Analysis

Site response analyses should be performed to evaluate peak horizontal accelerations of the OSDF foundation, liner system, and final cover system. Site response analyses should be performed using established one-dimensional or two-dimensional computer models such as SHAKE [Schnabel et al., 1972], as updated by Idriss and Sun [1992] for one-dimensional analyses, and QUAD4M [Hudson et al., 1994] for two-dimensional analyses. The selection of impacted-material parameters for seismic analyses should fully consider the existing site stratigraphy and subsurface conditions. The nature of the impacted materials that will be disposed in the OSDF (i.e., primarily soil, but also flyash, sludge, and building debris) should also be carefully considered in establishing these parameters.

The site response analyses will also require selection of representative earthquake magnitudes and strong motion acceleration-time histories. Guidelines that should be used to establish these inputs to the site response analyses include:

- *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities* [DOE, 1994];
- *RCRA Subtitle D (258) Seismic Design Guidance for Municipal Waste Landfill Facilities* [USEPA, 1995];
- *Uranium Mill Tailings Remedial Action Project, Technical Approach Document, Revision II* [DOE, 1989]; and
- *Pre-Design Investigation and Site Selection Report for the On-Site Disposal Facility* [DOE, 1995g].

The site response analyses should be used to obtain the peak average acceleration of the OSDF for evaluating stability of the OSDF liner system and foundation. The analyses should also be used to obtain the peak horizontal acceleration of the final cover system (at the level of the critical cover system interface for the evaluation of seismic performance of that component of the OSDF).

Pseudo-Static Stability Analysis

Pseudo-static stability analyses should then be performed using the acceleration values identified above. The evaluation should establish whether the pseudo-static factor of safety for the critical case for each stability condition is larger than 1.0. This minimum acceptable pseudo-static factor of safety is consistent with the *UMTRA Technical Approach Document* [DOE, 1989] and other engineering guidance. The stability conditions for which pseudo-static analyses should be performed are as follows:

- OSDF foundation
  - interim impacted-material configuration
  - final OSDF configuration
- OSDF impacted-material configurations
  - interim impacted-material configuration
  - final OSDF configuration
- OSDF final cover system
  - long-term condition on final side slope
- OSDF perimeter access corridor
  - long-term conditions

Deformation Analysis

If any of the above analyses result in a factor of safety less than 1.0, seismic deformation analyses will be performed to establish whether calculated deformations are within acceptable limits. If the calculated deformations are acceptable, then the adequacy of the design with respect to the specific design criteria should be considered acceptable. Deformation analyses should be performed using a Newmark [1965] sliding block approach, as coded in the computer program YSLIP_C [Yan, 1991], or other suitable method. In performing these analyses, large-displacement shear strengths should be assumed for liner and cover system geosynthetic interfaces.

2.3.2.3 Foundation Settlement

A. Criteria

- The settlement of the foundation should not cause grade reversal of the leachate collection layer or ponding of leachate on the liner system (design considerations).
- Geomembrane and geosynthetic clay liner materials and their seams, as well as leachate collection and leak detection piping, should be able to withstand stresses and deformations resulting from settlement of adjacent materials without exceeding allowable tensile strains and elongations (design consideration).
- The post-settlement slopes of the leachate collection system should be sufficient to convey leachate from the OSDF to the leachate transmission system gravity line (design consideration). The post-settlement slopes of the leachate transmission gravity line should be sufficient to convey leachate by gravity to the permanent lift station (design consideration).

B. Calculations

Calculations should be performed to evaluate the settlement of the foundation beneath the OSDF. The calculations should be performed as described below.

- The geotechnical characteristics (i.e., consolidation properties, unit weights, moisture characteristics, etc.) of the foundation materials and impacted materials should be evaluated using the site-specific data identified in Section 1.5 of this DCP. Correlations between soil index and compressibility properties can be obtained from Duncan and Chang [1970], Holtz and Kovacs [1981], Kulhawy and Mayne [1990], or other suitable references.
- The depth of influence should be estimated for the stress that will be applied to the foundation soils by the OSDF. The depth of influence may be estimated

based on methods presented by Perloff et al. [1967], Poulos and Davis [1974], or others, and should consider the effects of varying heights of fill at different locations within the OSDF.

- The settlement of each layer of the foundation should be calculated based on the calculated stress increase and the properties of the foundation materials using standard settlement calculation methods, such as those presented by Lambe and Whitman [1969], Duncan [1992], Duncan, et al. [1987], Holtz and Kovacs [1981], or others, as appropriate.

- The impact of the calculated settlement should be evaluated. The calculation results should be evaluated in terms of total settlements, differential settlements, change in slope of the leachate collection system, change in slope of the leachate transmission system gravity line, and impacts (if any) to the liner system components.

2.3.2.4 Impacted Material Settlement

A. Criteria

- Final cover system slopes after settlement should be large enough to prevent ponding of water on the final cover system (design consideration).

- Differential settlement of the OSDF final cover system resulting from compression of impacted material placed in the OSDF should not cause grade reversal of the final cover system (design consideration).

- The OSDF final cover system drainage layer should convey the design flow with a hydraulic head of not more than 1.0 ft under the post-settlement grades of that system (design consideration).

- Tensile strains in geosynthetic and soil components of the final cover system due to differential settlement must not cause damage to the components (design consideration).

B. Calculations

Calculations should be performed to evaluate the settlement of the OSDF final cover system. The calculations should be performed as described below.

- The layout of impacted materials in the OSDF should be established using information in the OSDF *Impacted Materials Placement Plan.*

- The geotechnical characteristics (i.e., consolidation properties, unit weights, moisture characteristics, etc.) of the impacted materials should be evaluated using the site specific data described in Section 1.5 of this DCP, other available information on the characteristics of materials to be placed in the OSDF, and information in the OSDF *Impacted Materials Placement Plan.*

- The potential for localized differential settlement due to impacted material non-homogeneity (i.e., "compressible zones" and "hard spots") should be evaluated considering the placement of the specific categories of impacted material allowed by the OSDF *Impacted Materials Placement Plan.* The potential for localized differential settlement should be evaluated using techniques such as those presented by Attewell [1987], Sagaseta [1987], Jones and O'Rourke [1988], Whittaker and Reddish [1989], Drumm et al. [1990], and Othman et al. [1995], or other suitable methods.

- Calculations should be performed to evaluate the potential magnitude of total settlement of the impacted material placed in the OSDF. The settlement calculation should use the same techniques as for foundation settlement (cited above), taking into account the specific geotechnical characteristics of the impacted material when placed in the OSDF in the manner required by the *Impacted Material Placement Plan.*

- Potential effects of the calculated settlement of both the foundation and impacted materials on the final cover system should be evaluated. The impact may be evaluated in terms of: total settlements, differential settlements, changes in slope to the final cover system drainage layer, hydraulic head in the final cover system drainage layer, and stresses and strains in final cover system components.

2.3.3 References

FEMP property data and information required for geotechnical slope stability and settlement analyses should be obtained from the references cited in Section 1.5 of this DCP. Additional information may be obtained from the general technical literature cited below.

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2.4 <u>Liner System</u>

2.4.1 General Design Criteria

The function of the liner system is to isolate impacted material from the environment while containing and collecting leachate generated by the material. As shown on Figure 1-1, the liner system will contain two liners (i.e., primary and secondary liners), separated by a leak detection system, with the primary liner overlain by a leachate collection system (ARAR: 40 CFR §265.301(a)). Both the primary and secondary liners will consist of a geomembrane overlying a geosynthetic clay liner; in addition, these components of the secondary liner will be underlain by a 3-ft thick layer of compacted, low-permeability clay (i.e., a clay with a hydraulic conductivity not more than 1×10^{-7} cm/s (ARAR: OAC 3745-27-08(C)(1)(j)(ii))).

Additional requirements of the OSDF liner system are as follows:

- The liner system will be effective for up to 1,000 years, to the extent reasonably achievable, and in any case for at least 200 years (ARAR: 40 CFR §192.02(a)).
- The liner system should extend completely under all areas where impacted material will be placed in the OSDF (design consideration).

- The liner system should be constructed in a manner that, after placement of the final cover system, completely encapsulates the impacted material placed in the OSDF (design consideration).

- The number of penetrations through the liner system by leachate collection and leak detection piping should be minimized. In particular, there should be no more than one penetration each for the leachate collection pipe, redundant leachate collection pipe, and leak detection pipe for each cell of the OSDF (design consideration).

- The liner system should be designed to resist damage caused by the loads applied during construction, placement of impacted material, closure, and post-closure care (design consideration).

- The liner system components should be adequately protected from damage due to desiccation, freeze/thaw cycles, wet/dry cycles, and the intrusion of objects during construction, filling, and closure (design consideration).

- The geosynthetic components of the liner system will be physically and chemically resistant to attack by the material to be disposed in the OSDF, leachate, or other materials that they may contact. This will be established using documented data or testing using USEPA Method 9090. Geosynthetic materials will also have properties acceptable for installation and use in the OSDF (ARARs: OAC 3745-27-08(E)(1) and (2)).

2.4.2 Hydrostatic Uplift

A. Criteria

The liner system will have a factor of safety of 1.4 against hydrostatic uplift (ARAR: OAC 3745-28-08(C)(1)(k)).

B. Calculations

To satisfy the above design criterion, an analysis should be performed of the impacts of potential hydrostatic forces on the liner system. The analysis should consider the potential range of perched-zone ground-water levels within the OSDF foundation. A contour map should be prepared to establish design-basis perched ground-water levels to use in the analysis. If the design-basis perched ground-water levels exceed the elevations of the bottom of the liner system, an analysis should be conducted to evaluate the potential for uplift of the liner system. The analysis should be performed for both end-of-construction and long-term conditions. Procedures for calculating uplift pressures due to high ground water are given in Lambe and Whitman [1969] and Holtz and Kovacs [1981], for example. If the minimum required factor of safety is not achieved in the calculations, then the project design should be modified as necessary. Potential modifications that may be considered include raising the bottom elevation of the OSDF, installing an underdrain system beneath the OSDF, placing ballast (e.g., gravel) in an OSDF cell to compensate for buoyant uplift, or using a temporary dewatering system until the OSDF is ballasted by impacted material disposed in the OSDF.

2.4.3 Compacted Clay Liner

The compacted clay liner will satisfy the requirements of OAC 3745-27-08(C)(1). Specifically, the compacted clay liner will be constructed:

- using loose lifts 8 in. thick; each lift will have a maximum hydraulic conductivity of 1×10^{-7} cm/s (ARAR: OAC 3745-27-08(C)(1)(a));
- of a soil with a maximum clod size of 3 in., or half the compacted lift thickness, whichever is less (ARAR: OAC 3745-27-08(C)(1)(b)); and
- of a soil with:
    - 100 percent of the particles having a maximum dimension not greater than 2 in.;
    - not more than 10 percent of the particles, by weight, having a dimension greater than 0.75 in.;

- not less than 50 percent of the particles, by weight, passing through the standard U.S. No. 200 standard sieve; and
- not less than 25 percent of the particles, by weight, having a maximum dimension not greater than 0.002 mm (2 μm) (ARAR: OAC 3745-27-08(C)(1)(c)).

The requirements of the initial two items appear to be satisfied by all of the brown and gray till underlying the FEMP property (excluding localized sand and gravel lenses). In contrast, the requirements of the final two items are satisfied by most, but not all, of the brown and gray till underling the FEMP property. However, OAC 3745-27-08(C) states that alternatives to the prescriptive requirements for soil liner materials may be used: "*...if it is demonstrated to the satisfaction of the Director that the materials and techniques will result in each lift having a maximum permeability of* 1×10^{-7} *cm/s.*" The available test data demonstrate that the brown and gray tills are capable of achieving a hydraulic conductivity no larger than 1×10^{-7} cm/s. Therefore, for the brown and gray till to be used in the compacted clay liner, a demonstration will be required pursuant to OAC 3745-27-08(C) to obtain an acceptable alternate to the particle size requirements. The primary considerations in developing this demonstration are given below:

- The primary performance criterion for compacted soil liners in OAC 3645-27-08(C)(1)(a) requires that each lift of the liner have a maximum hydraulic conductivity of 1×10^{-7} cm/s. The hydraulic conductivity of a clayey soil is, in part, a function of the percentage of clay-size particles. However, other factors such as soil plasticity, compaction moisture content, and dry density also strongly influence hydraulic conductivity. Benson et al. [1994] performed detailed analyses of how each of these parameters correlate with hydraulic conductivity. The results of their study, which was based on data from 67 landfills, indicate that an average (rather than a minimum) fraction of clay-sized particles exceeding 15 percent is an acceptable criterion for compacted soil liners. In addition, Benson et al. [1994] provide data on a large number of compacted soil liners which do not meet the clay-size particle criterion set forth in OAC 3745-27-08(C)(1)(c)(iv), yet, when constructed using appropriate procedures, have measured hydraulic conductivities less than 1×10^{-7} cm/s. It is also noted that widely-accepted guidelines for clay liner materials (e.g., Daniel [1993]) do not contain criteria for the minimum acceptable percentage, by weight, of clay-size particles. These same guidelines only require not less than 20 to 30 percent of the particles, by weight, to be finer than a U.S. No. 200 standard sieve.

- As part of the OSDF design, a test pad program will be conducted using soil obtained from the OSDF foundation excavation and the on-site soil borrow area. The test pads will be constructed using equipment and/or techniques that will subsequently be used to construct the OSDF compacted clay liner. Laboratory and field permeability testing will be performed during the test pad program to define the compaction conditions that will yield a soil liner with a hydraulic conductivity of not greater than 1×10^{-7} cm/s. The test pad program will meet the requirements for test pads set forth in OAC 3745-27-08(C)(1)(m).

- The results of the test pad program, including all laboratory and field hydraulic conductivity test results from the program, will be presented in a report that DOE will provide to USEPA and OEPA. This report will specify construction equipment types and construction procedures that result in a compacted clay liner satisfying the hydraulic conductivity performance criterion of OAC 3745-27-08(C)(1).

- During construction of the OSDF liner system, a detailed construction quality assurance (CQA) program will be implemented in accordance with OAC 3745-27-08(F). The CQA activities will include moisture/density testing of soil liner materials at the frequency required by OAC 3745-27-08(C)(1)(o) (i.e., no less than five tests per acre per lift (12 tests per hectare per lift)) to verify that the compaction conditions are consistent with those established during the test pad program, and monitoring activities in accordance with 40 CFR §264.303(C). In so doing, a high level of assurance will be provided that the hydraulic conductivity of the soil liner material is not greater than 1×10^{-7} cm/s. The CQA program will also include confirmatory hydraulic conductivity testing as required by OAC 3745-27-08(D)(1).

In addition to the foregoing, the compacted clay liner will:

- be compacted to at least 95 percent of the maximum standard Proctor dry density (ASTM D 698), or at least 90 percent of the maximum modified Proctor dry density (ASTM D 1557) (ARAR: OAC 3745-27-08(C)(1)(d));

- be compacted at a moisture content at or wet of optimum (ARAR: OAC 3745-27-08(C)(1)(e));

- not be comprised of solid waste (ARAR: OAC 3745-27-08(C)(1)(f));

- be constructed using the number of passes and lift thickness, and the same or similar type and weight of compaction equipment, used to obtain acceptable results during the soil liner test pad program (ARAR: OAC 3745-27-08(C)(1)(g));

- be placed on the bottom and excavated exterior slope of the OSDF and have a minimum bottom slope of 2 percent and a maximum slope based on: (i) compaction equipment limitations; (ii) slope stability; (iii) maximum shear strength between soil-geosynthetic and geosynthetic-geosynthetic interfaces; and (iv) resistance of geosynthetics and geosynthetic seams to tensile stresses (ARAR: OAC 3745-27-08(C)(1)(h));

- be constructed on a prepared surface that is: (i) free of debris, foreign material, and deleterious material; (ii) be able to bear the weight of the OSDF without causing or allowing a failure of the compacted clay liner to occur through settling; and (iii) without abrupt changes in grade that could cause damage to the geosynthetics (ARAR: OAC 3745-27-08(C)(1)(i)); and

- be adequately protected from damage due to desiccation, freeze/thaw cycles, wet/dry cycles, and the intrusion of objects during construction, filling, and closure (ARAR: OAC 3745-27-08(C)(1)(l)).

The OU2 ARARs contain requirements for testing the compacted clay liner during construction. These requirements must be incorporated into the OSDF construction specifications. The ARARs (OAC 3745-27-08(D)(1)) indicate that the following tests will be performed on representative samples of the clay to be used for liner construction at a frequency not less than 1 per 1,500 yd^3 of soil, except the hydraulic conductivity test, which will be performed at a frequency not less than 1 per 10,000 yd^3:

- hydraulic conductivity on specimens compacted to achieve the conditions described in the construction specifications;

- moisture content and dry density using an approved ASTM method;

- particle size distribution using the test method contained in ASTM D 422 for sieve and hydrometer analyses; and

- Atterberg limits using the test method contained in ASTM D 4318.

2.4.4 Geosynthetic Clay Liner

A. Criteria

The geosynthetic clay liner will (ARAR: OAC 3745-27-08(C)(3)):

- be negligibly permeable to fluid migration (C)(3)(a)) (interpreted herein to require that the GCL have a maximum hydraulic conductivity of 5×10^{-9} cm/s under applicable normal stresses) (C)(3)(a));

- be installed having a minimum overlap of 6 in. for side panel seams, or, for end of panel seams, a minimum overlap of 12 in. (overlap will be increased in accordance with manufacturer's specifications or to account for shrinkage due to weather conditions) (C)(3)(b));

- have a bentonite mass per unit area of at least one pound per square foot (5 kg/m^2) (C)(3)(c));

- be installed in accordance with the manufacturer's specifications in regard to handling, overlap, shingling, and the use of granular or powdered bentonite to enhance bonding at the seams (C)(3)(d)); and

- for the secondary liner component of the liner system, be constructed above the compacted clay liner (C)(3)(e)).

In addition to the foregoing requirements, the geosynthetic clay liner should be of the "internally reinforced" type. This type of geosynthetic clay liner will improve short-term liner system stability compared to the level of stability achieved with an "unreinforced" type geosynthetic clay liner (design consideration). The benefits of geosynthetic clay liner internal reinforcement or partial hydration should be discounted in evaluating the long-term stability of the liner system (i.e., the geosynthetic clay liner should be considered unreinforced and fully hydrated for long-term stability analyses).

B. Calculations

The design of OSDF liner system should include further evaluation of the most appropriate types of geosynthetic clay liners to use on this project (design consideration).

2.4.5 Geomembrane Liner

A. Criteria

The geomembrane component of the liner system will:

- be placed on the compacted clay liner (ARAR: OAC 3745-27-08(C)(2)); this is interpreted herein to mean that the geomembrane components of the OSDF liner system should be placed on top of the geosynthetic clay liner components;
- be manufactured of at least 60-mil thick high density polyethylene (ARAR: OAC 3745-27-08(C)(2));
- be negligibly permeable to fluid migration (ARAR: OAC 3745-27-08(C)(2)(a));
- be physically and chemically resistant to attack by solid waste, leachate, or other materials which may come in contact with the geomembrane (ARAR: OAC 3745-27-08(C)(2)(b));
- be seamed to allow no more than negligible amounts of leakage; the seaming material will be physically and chemically resistant to attack by solid waste, leachate, or other materials that may come in contact with the seams (ARAR: OAC 3745-27-08(C)(2)(c));
- have acceptable properties for installation and use (ARAR: OAC 3745-27-08(C)(2)(d)); and
- as necessary, be protected from the overlying leachate collection system by a cushion layer (ARAR: OAC 3745-27-08(C)(2)(e)).

The ARARs cited above require that the geomembrane components of the liner system be at least 60 mil thick. As a design enhancement to increase the service life of the OSDF liner system, the use of a thicker geomembrane (e.g., an 80-mil thick) material should be considered (design consideration). Consideration should also be given to using "textured" geomembrane, as opposed to smooth geomembrane, to improve OSDF slope stability (design consideration).

The OU2 ARARs also contain specific requirements for geomembrane seam testing. These requirements will be incorporated into the OSDF construction specifications. The OU2 ARARs require that geomembrane seams be tested in accordance with the following, unless the geomembrane manufacturer's specifications for testing are more stringent, in which case the manufacturer's specifications should be used:

- for the purpose of testing every seaming apparatus in use each day, peel and shear tests will be performed on scrap pieces of geomembrane at the beginning of the seaming period and every 4 hours thereafter (ARAR: OAC 3745-27-08(C)(2)(g)(i));

- nondestructive testing will be performed on 100 percent of the geomembrane seams (ARAR: OAC 3745-27-08(C)(2)(g)(ii)); and

- destructive testing for peel and shear will be performed at least once every 500 ft of seam length (ARAR: OAC 3745-27-08(C)(2)(g)(iii)).

As part of the design of the OSDF liner system, an evaluation should be performed to establish whether a textured geomembrane manufactured of HDPE and of 80 mil thickness is the most appropriate type of geomembrane (in terms of composition, thickness, surface texturing, etc.) for use on the project. The evaluation should consider physical and mechanical properties, durability, and chemical compatibility (design consideration).

B. Calculations

The evaluation described above should be performed as part of the OSDF liner system design.

2.4.6 Geotextile Cushion

A. Criteria

The geomembrane component of the liner system should be designed to resist puncture or damage from the stresses applied by overlying drainage layer material. This may require the use of a geotextile cushion layer (design consideration). The geotextile cushion layer should also be designed to be robust and have adequate construction survivability characteristics (design considerations).

B. Calculations

The calculation for evaluating geotextile cushion layer requirements should consider two loading conditions: (i) long-term case assuming the OSDF is full; and (ii) short-term case assuming that construction equipment is working above the drainage layer material. Procedures such as those by Koerner et al. [1995], or other suitable procedures, should be used to calculate the required characteristics of the geotextile cushion. If the procedure by Koerner et al. [1995] is used, the geotextile cushion layer should be designed to have a factor of safety of 3.0.

Design for adequate construction survivability should be performed using the procedure described in Koerner [1994], or other suitable procedures.

2.4.7 Geosynthetic Tension and Anchor Trench Capacity

A. Criteria

The geosynthetic components of the liner system should be designed to prevent slippage at their interfaces with adjacent materials and, thus, to preclude the development of tension in these materials (design consideration).

Notwithstanding the fact that the geosynthetics will be designed to preclude the development of tensile stresses, an anchor trench should be constructed at the top of the OSDF side slope to anchor the geosynthetic components of the liner system. The purpose of the anchor trench is to facilitate installation of the geosynthetics and to prevent disturbance of the geosynthetics by wind prior to placement of overlying soil layers. To achieve these functions, the anchor trench should be 2 ft deep. Based on industry experience, this depth of anchor trench will satisfy the functional requirements.

B. Calculations

An evaluation should be performed to establish that slippage at geosynthetic component interfaces will not occur. The evaluation should involve a comparison of the interface shear strengths of geosynthetic components to the mobilized shear stresses along the interfaces. The factor of safety in every case should be larger than 1.0 to prevent the development of geosynthetic tension. The work of Long et al. [1994] should be considered in performing the evaluation.

2.4.8 Frost Protection

A. Criteria

As discussed in Section 2.4.3 of this DCP, the compacted clay liner component of the liner system will be adequately protected from damage due to freeze/thaw cycles (ARAR: OAC 3745-27-08(C)(1)(l)). This is achieved by having an adequate thickness of insulating material (e.g., soil) on top of the clay during freezing weather. An evaluation of the required thickness of overlying material is required.

B. Calculations

An evaluation should be performed to identify the minimum thickness of soil that must be placed over the geomembrane component of the secondary liner to protect the underlying compacted clay liner component from freeze-thaw due to winter weather. The evaluation should be performed using the modified Berggren method [Aldrich and Paynter, 1953]. The evaluation should be performed using climatological data relevant to the OSDF locale.

2.4.9 Chemical Compatibility

Geosynthetic materials, including seams, joint sealing compounds, and other synthetic materials used to construct the OSDF liner system will be physically and chemically resistant to attack by the leachate that will be generated by the facility (ARAR: OAC 3745-27-08(E)(1)). To satisfy this requirement, a liner compatibility study should be implemented to demonstrate the compatibility of the geomembrane component of the liner system with the anticipated OSDF leachate. The liner compatibility study should be performed in two parts with the first part consisting of a review of published data on: (i) the general chemical compatibility and durability characteristics of HDPE geomembranes; and (ii) the performance of HDPE geomembranes in similar applications. If the available published data are not adequate to draw conclusions for design, a physical/chemical testing program should be undertaken to generate additional data. The testing program should include:

- immersion of representative geomembrane specimens in simulated OSDF leachate; the immersion procedures should be in accordance with USEPA Method 9090;
- pre- and post-immersion physical, mechanical, and micro-structural testing of the geomembrane specimens; and
- evaluation of the test results for evidence of any adverse impacts of leachate immersion on the geomembranes.

The scope of the liner compatibility study should be described in a work plan that addresses both the literature review and the physical/chemical laboratory testing program. The work plan should provide a detailed description of the immersion testing procedures and the procedures that will be used to evaluate the test results, should testing prove necessary. The work plan should first be developed in draft form for DOE, USEPA, and OEPA review and approval. A final work plan should be issued after incorporation of comments on the draft. A final report should be submitted to DOE, USEPA, and OEPA upon completion of the study.

The liner compatibility study should be complete prior to completion of the final design package.

A liner compatibility study cost estimate should be prepared based on the draft liner compatibility study work plan. The cost estimate must be in Fluor Fernald, Inc. (formerly FERMCO) format. This format is illustrated by the Fluor Fernald, Inc. (formerly FERMCO) baseline OSDF cost estimate presented in Appendix E of this document.

2.4.10 References

FEMP property data and information required for design of the liner system should be obtained from the references cited in Section 1.5 of this DCP. Additional information for design may be obtained from the general technical references listed below.

Aldrich, H.P. and Paynter, H.M., "Frost Investigations, Fiscal year 1953, First Interim Report", *Analytical Studies of Freezing and Thawing Soils*, Arctic Construction and Frost Effects Laboratory, New England Division, U.S. Army Corps of Engineers, Boston, MA, 1953.

Benson, C.H., Zhai, H., and Wang, X., "Establishing Hydraulic Conductivity of Compacted Clay Liners", *ASCE Journal of Geotechnical Engineering*, Vol. 120, No. 2, Feb 1994, 366 to 387 p..

Giroud, J.P. and Bonaparte, R., Leakage through Liners Constructed with Geomembranes, Part I: Geomembrane Liners", *Geotextiles and Geomembranes*, Vol. 8, No. 1, 1989a, pp. 27-67.

Giroud, J.P. and Bonaparte, R. "Leakage through Liners Constructed with Geomembranes, Part II: Composite Liners", *Geotextiles and Geomembranes,* Vol. 8, No. 2, 1989b, pp. 71-111.

Giroud, J.P., Badu-Tweneboah, K., and Bonaparte, R., "Rate of Leakage Through a Composite Liner Due to Geomembrane Defects", *Geotextiles and Geomembranes*, Vol. 11, No. 1, 1992, pp. 1-28.

Holtz, R.D. and Kovacs, W.D., "*An Introduction to Geotechnical Engineering*", Prentice Hall, Englewood Cliffs, New Jersey, 1981, 733 p.

Koerner, R.M., "*Designing with Geosynthetics*", Third Edition, Prentice Hall, Englewood Cliffs, NJ, 1994, 783 pp.

Koerner, R.M., Wilson-Fahmy, R.F., and Narejo, D.B., "*Puncture Protection of Geomembranes, Part I: Theory, Part II: Experimental, and Part III: Examples*", Geosynthetic Research Institute, 1995.

Lambe, T.W. and Whitman, R.V., "*Soil Mechanics*", John Wiley and Sons (Pub.), 1969, pp. 359-365.

Long, J.H., Gilbert, R.B. and Daly, J.J., "Geosynthetic Loads in Landfill Slopes: Displacement Compatibility", *Journal of Geotechnical Engineering*, ASCE, Vol. 120, No. 11, November 1994, pp. 2009-2025.

2.5 Leachate Management

2.5.1 Leachate Collection System

A. Criteria

The functions of the leachate collection system are to collect leachate, route it from the OSDF to the leachate transmission system, and limit the buildup of hydraulic head on the underlying primary liner (functional requirements). The leachate collection system should also extend over all areas that will subsequently be used for impacted material disposal and functionally, the system should be designed to accommodate operation, monitoring, and maintenance with minimal difficulty (design considerations). In addition to the foregoing requirements, the leachate collection system should comply with the design criteria given below:

- The leachate collection system for a given OSDF cell should be independent of the leachate collection systems for adjacent cells (design consideration).

- During impacted material placement, the leachate collection system for a cell, coupled with the configuration of perimeter and intercell side slopes of the cell, will provide control (containment) of runoff from active portions of the disposal facility for the 25-year, 24-hour storm event (ARAR: 40 CFR §258.26). For the FEMP property, this event has a rainfall intensity of 4.7 in. [Parsons, 1995a]. Temporary ditches and perimeter and intercell berms should have freeboard of at least 0.5 ft under the design storm event (design consideration).

- The leachate collection system will be designed to limit the leachate head in the system to less than 12 in. (ARARs: OAC 3745-27-08(C)(4) and 40 CFR §258.40). The evaluation of maximum head should consider initial and intermediate filling conditions in a cell, as well as conditions after closure (design consideration). The evaluation need not consider potential transient higher heads due to rainfall that might fall into an open cell during cell start-up activities (design consideration).

- The leachate collection system will be designed to resist clogging and crushing (ARAR: OAC 3745-27-08(C)(4)).

- The leachate collection system will consist of a drainage layer placed on top of the geomembrane component of the primary liner (ARAR: OAC 3745-27-08(C)(4)(a)).

- The leachate collection system drainage layer material will have a hydraulic conductivity, k, of at least 1×10^{-3} cm/s, be at least 1 ft thick, and have a negligible amount of fines (ARARs: OAC 3745-27-08(C)(4)(a)(i) through (iii)). The fines content requirement is interpreted herein to mean not more than 2 percent of the particles passing a U.S. No. 200 standard sieve.

- The leachate collection system drainage layer material will not contain carbonate material (ARAR: OAC 3745-27-08(C)(4)(a)(iv)), unless it is shown to the satisfaction of USEPA and OEPA that a material containing carbonate meets the design requirement. Material is considered to meet the carbonate content requirement if it satisfies the requirements of the 18 August 1994 OEPA Department of Solid and Industrial Waste Management (DSIWM) Interpretation entitled "*Carbonate Content of Drainage Layer*".

- Earth materials (i.e., non-carbonate, durable, sound aggregate), not geosynthetic drainage layers, should be used in the leachate collection system to the extent possible to maximize the design life of the system (design consideration). An alternative material requirement may be used for the leachate collection system if it is demonstrated to the satisfaction of the USEPA and OEPA that the alternative satisfies all other design requirements.

- The leachate collection system will contain a means to remove leachate from the bottom of the landfill (ARAR: OAC 3745-27-08(C)(4)(b)).

- Leachate collection system pipes will (as required by OAC 3745-27-08(C)(4)(b)):

  - be imbedded in the drainage layer ((4)(b)(i));

  - be constructed with a minimum slope of 0.5 percent ((4)(b)(ii));

  - be provided with access for clean-out devices ((4)(b)(iii));

- have lengths and a configuration that do not exceed the capabilities of clean-out devices ((4)(b)(iv));
- have welded joints to prevent separation ((4)(b)(v)); and
- be physically and chemically resistant to attack by the solid waste, leachate, or other materials they may contact ((4)(b)(vi)).

- A leachate collection system without a pipe network may be used if it is demonstrated that the system is in compliance with the 27 January 1995 DSIWM guidance document entitled "*Leachate Collection System Design - Use of a Drainage Layer without a Pipe Network*" (design consideration). This document requires that:
  - the leachate collection system limits the leachate head in the system to less than 12 in. (design consideration);
  - the drainage layer has adequate permeability to minimize clogging potential (design consideration);
  - the leachate collection system is constructable, provides easy access for maintenance and repair, is reliable and redundant, and is properly sized (design consideration); and
  - the leachate collection system is physically and chemically resistant to attack by solid waste and leachate (design consideration).

- It is noted that the clean-out device requirement given above (OAC 3745-27-08(C)(4)(b)(iii)) is interpreted to apply to any length of pipe required to maintain a leachate head of less than 12 in. on the primary liner. Additional pipe installed for redundancy need not meet this requirement (design consideration). In addition, leachate collection system pipes should be designed to resist stresses due to overburden materials and construction equipment (design consideration).

- The collection pipe network of the leachate management system will be inspected after placement of the initial lift of impacted material to ensure that crushing has not occurred and annually thereafter to ensure that clogging has not occurred (ARAR: OAC 3745-27-19(K)(3)). Consistent with the interpretation of the previous ARAR, the requirements of this ARAR are interpreted to apply to any length of pipe required to maintain a leachate head of less than 12 in. on the primary liner. Additional pipe installed for redundancy need not meet these requirements (design consideration).

- The leachate collection system will be overlain by a filter layer to prevent (to the extent possible) clogging of the drainage layer (ARAR: OAC 3745-27-08(C)(4)(c)).

- Leachate collection system pipes should be at least 6 in. in nominal diameter to minimize clogging potential and to provide ample access for clean-out equipment (design consideration).

- Leachate collection system pipes should be manufactured from HDPE for durability and chemical compatibility (design consideration). These pipes should have a standard dimension ratio (SDR) of no more than 11 to provide both a high degree of structural stability and a wall thickness sufficient to minimize the potential for surface degradation (e.g., oxidation) and therefore maximize the design life of the system (design consideration).

- Portions of leachate collection system pipes inside a cell should be perforated to allow inflow of leachate. Perforations should be designed to prevent plugging or clogging by the adjacent drainage material (design consideration).

- The factors of safety for flow in the leachate collection system pipes under the various design flow conditions are as follows:

    - baseline design flow rate during OSDF operations (i.e., baseline leachate flow obtained from leachate generation analysis; this baseline excludes temporary flows from surface-water runoff that is contained in the cell and allowed to percolate directly into the cell leachate collection system); the minimum acceptable factor of safety for this condition is 3.0;

    - storm design-basis flow rate during OSDF operations (i.e., baseline leachate flow plus temporary flows from surface-water runoff that is contained in the cell and allowed to percolate directly into the cell leachate collection system); the storm design-basis flow rate should be mechanically controlled during active OSDF operations to satisfy the following competing criteria:

(i) rapid drainage of cell surface-water runoff; (ii) permanent lift station operational requirements; and (iii) maximum acceptable discharge rate to the biosurge lagoon; the minimum acceptable factor of safety for temporary pressure flow capacity in the permanent leachate transmission system gravity line for this condition is 1.0; the minimum acceptable factor of safety for hydrostatic rupture in a pressurized pipe in the permanent leachate transmission system gravity line is 1.5 using as a basis the manufacturer pressure rating for the carrier pipe; and

- baseline design flow rate after OSDF closure (i.e., baseline flow obtained from leachate generation analysis); the minimum acceptable factor of safety for this condition is 10.0.

- The leachate collection system should be designed to route liquid from each cell to an enclosed location (i.e., valve house) outside of the OSDF where the liquid flow rate can be periodically monitored and the liquid sampled without significant difficulty (design consideration).

- The leachate collection system should be provided with a redundant drain pipe to serve as a back-up in the event of unforeseen problems with the main leachate collection system pipe (design consideration).

- A protective layer will be placed above the leachate collection system to protect the underlying liner system from damage due to intrusion of objects (ARAR: OAC 3745-27-08(C)(4)(d)).

- The protective layer should consist of a minimum 1 ft thickness of impacted or non-impacted soil that contains no sharp objects, debris, or other material that could damage the liner system (design consideration).

In addition to the foregoing, the OU2 ARARs contain requirements for testing the granular material that will be used to construct both the leachate collection system and the leak detection system. These requirements must be incorporated into the OSDF construction specifications. The ARARs (OAC 3745-27-08(D)(2)) indicate that the following tests will be performed on representative samples of the granular material at a frequency of not less than 1 per 3,000 yd^3:

- hydraulic conductivity; and

- particle-size distribution using ASTM D 422 or ASTM C 136 for the sieve method.

B. Calculations

The quantity of leachate generated in an OSDF cell during filling and after closure should be evaluated as part of the design process. The quantity of leachate should be calculated using the USEPA Hydrologic Evaluation of Landfill (HELP) model, Version 3.03 [Schroeder et al., 1994a,b] or the most recent version after newer versions are released. Leachate generation estimates should be made for each representative step in the filling of an OSDF cell (i.e., after placement of an initial thickness of impacted material (initial filling), intermediate filling, and post-closure) and for each representative phase of OSDF development. The results of the calculations should be used to design the leachate collection system, leak detection system, and leachate transmission system.

Impacted runoff from active portions of the OSDF for the 25-year, 24-hour storm event should be calculated and containment of this runoff within the OSDF should be demonstrated. Impacted runoff volumes may be calculated as described in Technical Release 55, published by the United States Department of Agriculture-Soil Conservation Service [USDA-SCS, 1986a]. Impacted runoff routing calculations should be performed using Technical Release 55, or alternatively Technical Release 20 [USDA-SCS, 1975] techniques.

The following leachate collection system evaluations should be performed:

- maximum head in the leachate collection system, as calculated using the USEPA HELP computer model and checked using procedures presented by Giroud and Houlihan [1995], or other suitable methods;
- geotextile filter design, using procedures presented by Giroud [1982] or Christopher and Holtz [1984], or other suitable methods;
- geotextile biological clogging potential, using procedures by Koerner and Koerner [1995], and Koerner et al. [1994];
- flow capacity of leachate collection system pipes (using standard pipe capacity calculation methods) for the various design flow conditions;

- leachate collection system pipe perforation sizing (using an analysis based on the leachate collection system drainage material particle size distribution); and
- leachate collection system pipe structural stability (using standard methods for evaluating the strength and stability of buried flexible pipes).

2.5.2 Leak Detection System

A. Criteria

The following design criteria apply to the leak detection system:

- The leak detection system should allow monitoring of any leachate migration through the primary liner of each cell of the OSDF (functional requirement). The maximum leak detection time (i.e., the time between when leakage occurs and when it drains into the valve house) should be less than 20 days (design consideration), calculated assuming steady-state flow conditions.
- The leak detection system for a given OSDF cell should be independent of leachate detection systems for adjacent cells (design consideration).
- The leak detection system should be independent of the leachate collection system (functional requirement).
- The leak detection system should provide for efficient and reliable containment and collection of any leachate migration through the primary liner (design consideration).
- The leak detection system should limit the liquid head on the secondary liner to not more than 1 ft under normal and extreme operating conditions, be constructed of durable material, and not be prone to clogging or other forms of deterioration (design consideration).
- The leak detection system should be designed to route liquid from each cell to an enclosed location (i.e., valve house) outside of the OSDF where the liquid flow rate can be periodically monitored and the liquid sampled without significant difficulty (functional requirement).

- The leak detection system drainage material should meet the same design criteria and testing requirements identified in Section 2.5.1 for leachate collection system drainage material (design consideration).

- The leak detection system pipes should meet the same design criteria identified in Section 2.5.1 for leachate collection system pipes (design consideration).

An action leakage rate (ALR) should be defined for the leak detection system that establishes a threshold for response actions in the event of excessive flow rates from the leak detection system drain pipe (functional requirement). The ALR should be established in accordance with procedures for RCRA Subtitle C facilities, as described in 40 CFR §264. The ALR, monitoring to evaluate conformance with the ALR, and response actions to be taken in the event the ALR is exceeded will be described in the Ground-Water Monitoring Plan that will be prepared for the OSDF.

B. Calculations

The following calculations should be performed as part of the design of the leak detection system:

- the potential for leachate migration through the liner and into the leak detection system, using the USEPA HELP model [Schroeder et al., 1994a,b], which uses the liner performance models of Giroud and Bonaparte [1989a,b] and Giroud et al. [1992] to calculate a rate of leakage through the primary liner;

- hydraulic head in the leak detection system drainage layer due to the calculated leakage through the primary liner, using the procedure described in Bonaparte and Giroud [1995], or other suitable methods;

- time of travel in the leak detection system calculated using the procedure described in Bonaparte and Giroud [1995], or other suitable methods;

- leak detection system pipe flow capacity and factor of safety (using standard pipe capacity calculation procedures);

- leak detection system pipe perforation sizing (using an analysis based on the leak detection system drainage material particle size distribution);

- leak detection system pipe structural stability (using standard methods for evaluating the strength and stability of buried flexible pipes); and

- leak detection system ALR (using accepted procedures for RCRA Subtitle C facilities).

2.5.3 Leachate Transmission System

A. Criteria

The leachate transmission system must be designed to convey leachate (and liquids in the leak detection system) from the OSDF cells to a permanent lift station at the OSDF battery limit (functional requirement). From the permanent lift station, the leachate will be pumped through a double-wall forcemain pipe to the biosurge lagoon. This DCP addresses design of the leachate transmission system up to, and including, the permanent lift station physical structure and the controls on the leachate transmission gravity line outlet into the permanent lift station. The design of the forcemain from the permanent lift station to the biosurge lagoon, including permanent lift station pump requirements and valves, controls, and electrical/mechanical equipment downstream of the pumps, is being addressed in a separate design package.

ARARs relevant to the leachate transmission system are contained in OAC 3745-27-08(C)(5) which states that any leachate conveyance and storage structures located outside of the limits of disposal will be no less protective of the environment than the disposal facility, and will:

- be monitored, as required by EPA and OEPA ((C)(5)(a));

- for storage tanks, be provided with secondary containment ((C)(5)(b));

- for leachate lines, be provided with double containment ((C)(5)(c)); and

- for storage structures, have a minimum of one week of storage capacity as established by design using assumptions simulating final closure of the facility ((C)(5)(d)).

Additional ARARs for the leachate transmission system are as follows:

- At least one lift station back-up pump will be kept at the disposal facility at all times (OAC 3745-27-19(K)(2)).

- If authorized by the Ohio EPA Director or his authorized representative, DOE may temporarily store leachate within the limits of waste placement until the leachate can be treated and disposed as described in the Systems Plan, Collection and Management of Leachate for the On-Site Disposal Facility (OAC 3745-27-19(K)(4)).

The leachate transmission system (EPLTS) design criteria presented below have been developed to satisfy these ARARs as well as the functional requirements contained in Appendix D of this DCP and the design considerations normally associated with this type of system:

- The permanent EPLTS gravity line, EPLTS valve houses, a control valve house, and the permanent lift station, all discussed below, should be located on the west side of the OSDF, within or at the battery limit, outside of the 25-year, 24-hour storm flood line, and outside of the alignment of roads or utilities, such that it is not impacted by a 25-year, 24-hour flood.

- Each OSDF cell should have its own EPLTS valve house that contains the piping and controls necessary to convey liquid flows from the leak detection and leachate collection system pipes of the cell to the permanent EPLTS gravity pipe. The EPLTS valve house should provide secondary containment for all piping and tankage within the house. The valve house should be designed with adequate space for collection/monitoring system to allow safe and efficient system operation and maintenance.

- Liquid in the leak detection system of an OSDF cell should flow by gravity through a double-wall HDPE pipe which penetrates the liner system and extends into the EPLTS valve house for that cell. The EPLTS valve house should be located on the west side of the OSDF (outside the limit of impacted material disposal).

- In each EPLTS valve house, the leak detection system pipes, valves, and fittings should convey any leak detection system flow through a totalizing flow meter prior to discharge to the permanent EPLTS gravity pipe. The piping and valving configuration and metering system should allow for the periodic flow monitoring and sampling of any liquid conveyed by the leak detection system carrier pipe from the cell. The leak detection system containment pipe (i.e., the outer pipe component of the double-wall pipe) should have a monitoring port and fixed end seal within the EPLTS valve house. The flow metering system should provide accurate leak detection system flow rate estimates (± 3 percent) under the expected very low rates for this system.

- The leak detection system carrier pipe within each EPLTS valve house should have a cleanout that enables maintenance of the pipe. Any tankage used to temporarily store or otherwise manage leak detection system flows within the EPLTS valve house should be equipped with a level indicator for indirect flow measurement.

- Liquid in the leachate collection system of an OSDF cell should flow by gravity through a double-wall HDPE pipe which penetrates the liner system and extends into the same EPLTS valve house as the leak detection system piping for that cell. In each EPLTS valve house, the leachate collection system pipes, valves, and fittings should convey leachate through a totalizing flow meter prior to discharge to the permanent EPLTS gravity pipe. The piping and valving configuration and metering system should allow for the periodic flow monitoring and sampling of liquid conveyed by the leachate collection system carrier pipe from the cell. The flow metering system should provide accurate leachate collection system flow rate estimates (±3 percent) for the expected range of leachate generation rates in the cell.

  The leachate collection system carrier pipe within each EPLTS valve house should have a cleanout that enables maintenance of the pipe. Any tankage used to temporarily store or otherwise manage leachate collection system flows within the EPLTS valve house should be equipped with a level indicator for indirect flow measurement. The leachate collection system carrier pipe should have valves for regulating leachate flow into the permanent EPLTS gravity line during construction and periods of gravity line maintenance, extension, repair, etc.

- The redundant leachate collection system double-wall HDPE pipe from each OSDF cell should extend into the EPLTS valve house for that cell. The redundant carrier pipe should have a valve (secured in a closed position) and sampling port (for periodically draining the pipe and/or confirming the absence of liquid in the pipe). The carrier pipe valve should be configured so that pipes, valves, and fittings can be added within the valve house to allow redundant leachate collection system flow from the cell to the permanent EPLTS gravity line at a future date in the event of a failure of the primary leachate collection system pipe. The redundant leachate collection system containment pipe should have a monitoring port and fixed end seal within the EPLTS valve house.

- For ease of maintenance, leachate collection system and leak detection system pipes, valves, and fittings within each EPLTS valve house should be fabricated of carbon steel or chemical resistant flexible hose. Connections between HDPE pipe and carbon steel pipe components should be gasketed and flanged. Also for ease of maintenance, permanent EPLTS gravity line components within each valve house should also be fabricated of carbon steel. The design should require that the valves and steel piping be removed from each EPLTS valve house and replaced with SDR-11 HDPE piping prior to the end of the period during which the EPLTS will be maintained (so that, in the long term, there are no obstructions in the pipe and the entire pipe consists of HDPE which is more durable than carbon steel). Good practice should be used in designing the piping layout, installation requirements, operations and maintenance. Adequate space will be provided for safe and efficient access for inspection and maintenance. Valve and switches should be directly lockable to facilitate lockout/tagout requirements. The use of chains or other extra equipment is not an acceptable method to "lockout" the valve or switch. All valves, piping, and switches will be labeled as to service and flow direction. Valves and other control devices will be located and installed in accordance with good ergonomic practice for safe and effective operation.

- Within each EPLTS valve house, the leachate collection system pipes, valves, and metering system should be separate from the leak detection system pipes, valves, and metering system. Each system should be separately tied into the permanent EPLTS gravity line. Tie-ins should include check valves to prevent backflow and other valves and fittings to allow the permanent EPLTS gravity line, the leachate collection system line, and the leak detection system line to be separately maintained and serviced.

- The EPLTS valve houses should be designed to have sufficient size to house the leachate transmission system piping connections, valves, fittings, monitoring and sampling facilities, and ancillary equipment associated with each OSDF cell. Guidance in facility layout, equipment arrangement, piping design and layout, space allotment, and design maintenance considerations can be found in "Part II: Good Practices" of the DOE Handbook "Design Considerations", DOE-HDBK-1132-99, April 1999. The houses should be constructed of reinforced concrete designed to be structurally stable under earth, ground-water, wind, snow, and traffic loadings. Valve house roofs will be designed to be stable under wind, snow, seismic, and collateral loadings. The design of the houses should conform to applicable building code. These standards will include the America Institute of Steel Construction (AISC) Specification for Structural Steel Buildings-Allowable Stress Design and Plastic Design or Load and Resistance Factor Design Specifications. External loads to use in the design of the EPLTS valve houses foundations include at-rest earth pressures and perched ground-water pressures. The houses should be designed to withstand hydrostatic uplift (with a factor of safety of 1.4), sliding, and overturning due to the perched ground water and earth pressures. The design-basis perched ground-water contour map identified in Section 2.4.2 of this DCP should be used for EPLTS valve house design calculations. Valve houses should be designed with ventilation that provides six air changes per hour in accordance with *Recommended Standard for Water Works* [Upper Mississippi River Board of Public Health and Environmental Managers, 1996] for dry lift stations. Valve houses should also be provided with ingress/egress through lockable doors and stairs. Valve houses should be provided with adequate indoor and outdoor lighting for safe operations regardless of natural light conditions (day or night). In accordance with Illuminating Engineering Society and DOE guidelines, interior lighting should provide 30 foot-candles of light in the mechanical work areas. Valve houses should be provided with heating to prevent freezing of pipes without requiring heat tracing. Fire protection will be considered as required by DOE and USOSHA.

- To achieve the ARAR requirement for double containment, EPLTS valve houses should be provided with a water-tight protective seal over their interior surfaces. The seal should be of a durable material, resistant to degradation if exposed to leachate. The floor of each valve house should be provided with a sump designed to collect any free liquid that enters the house. Each sump should be equipped with a liquid level indicator and be accessible to pumps. Pump discharge may be to either an ancillary piping connection within the EPLTS valve house, or available tanker trucks for direct transport and disposal at either the permanent lift station or biosurge lagoon.

- The permanent EPLTS gravity line outside of the valve houses should consist of double-wall HDPE pipe having a minimum nominal diameter for the carrier pipe of 6 in. The maximum pipe SDR should be 11. The factors of safety for flow in the permanent EPLTS gravity line under the various design flow conditions are as follows:

  - baseline design flow rate during OSDF operations (i.e., baseline leachate flow obtained from leachate generation analysis; this baseline excludes temporary flows from surface-water runoff that is contained in the cell and allowed to percolate directly into the cell leachate collection system); the minimum acceptable factor of safety for this condition is 3.0;

  - storm design-basis flow rate during OSDF operations (i.e., baseline leachate flow plus temporary flows from surface-water runoff that is contained in the cell and allowed to percolate directly into the cell leachate collection system); the storm design-basis flow rate should be mechanically controlled during active OSDF operations to satisfy the following competing criteria: (i) rapid drainage of cell surface-water runoff; (ii) permanent lift station operational requirements; and (iii) maximum acceptable discharge rate to the biosurge lagoon; the minimum acceptable factor of safety for temporary pressure flow capacity in the permanent EPLTS gravity line for this condition is 1.0; the minimum acceptable factor of safety for hydraulic rupture in a pressurized pipe in the permanent EPLTS gravity line is 1.5, using as a basis the manufacturer pressure rating for the carrier pipe; and

  - baseline design flow after OSDF closure (i.e., baseline leachate flow obtained from leachate generation analysis); the minimum acceptable factor of safety for this condition is 10.0.

- The inner carrier pipe of the permanent EPLTS gravity line should be continuous over its entire length (i.e., from its upgradient end to its discharge point). This carrier pipe should be equipped with cleanouts internal to the valve houses. The cleanouts should be spaced to allow the entire line to be maintained. The outer containment pipe should be continuous between EPLTS valve houses, but open to allow discharge of any liquid into a collection container located in each valve house. The sump in each EPLTS valve house, discussed previously, should be periodically inspected for the presence of liquid which could be indicative of a possible leak in the permanent EPLTS carrier pipe, or in other pipes, valves, or fittings internal to the house. The EPLTS valve house sumps should be equipped with liquid level switches to indicate the presence of liquids.

- The permanent EPLTS gravity line should be located on the west side of the OSDF (outside of the limit of impacted material disposal). The gravity line should run the length of the OSDF, from the first cell near the north end of the facility to the last cell near the south end. From the last cell, the gravity line should run to the control valve house and permanent lift station. To promote gravity flow, the gravity line should be constructed with a minimum slope of 0.25 percent. The gravity line should be buried in a trench at a sufficient depth below ground to prevent freezing of liquids in the line and damage due to traffic loads and other stresses. The gravity line should be adequately bedded in the trench.

- A control valve house should be installed immediately upgradient of the permanent lift station. The control valve house should be designed to the same criteria as the EPLTS valve houses. The functions of the control valve house are to throttle flow, monitor the rate and volume of liquid sent to the permanent lift station and, protect the permanent lift station from overfilling due to flows in excess of permanent lift station pump capacity. A valve should be installed in the control valve house to provide a manual means for regulating or preventing flow into the permanent lift station. A flow meter capable of measuring total flow and flow rate should be installed in the control valve house. A motor-operated valve controlled by high level signals from the permanent lift station will be installed in the control valve house.

- The permanent lift station should be constructed of a HDPE material with physical and durability characteristics similar to the permanent EPLTS gravity line material. The permanent lift station should provide for secondary containment of liquids (OAC 3745-27-08((C)(5)6))). The secondary containment system of the permanent lift station should be designed so that it can be monitored for the presence of leakage and should be equipped with a liquid level alarm.

- The pumps for the permanent lift station should be sized to pump liquid through a double-wall forcemain to the biosurge lagoon. Pump capacity should be adequate to convey the design flow rates associated with each of the leachate transmission system flow conditions described previously. The pumps for the permanent lift station and the forcemain that will convey leachate from the permanent lift station to the biosurge lagoon will be designed as part of a separate design package.

- The permanent lift station should be protected from adverse effects due to leachate and differential settlement. The lift station should be equipped with an automatic high level alarm located no more than 6 ft above the invert of the gravity line lift station inlet. Lift station pumps will be of adequate capacity and will automatically commence pumping before the accumulated leachate activates the high level alarm (OAC 3745-27-08(C)(4)(e)). The lift station should also control a system for automatically closing the valve at the control valve house in the event of a power failure or if liquid levels in the lift station rise to an unacceptably high level (below the rim of the lift station or any level that would cause an electrical short or damage to equipment in the lift station).

- The permanent lift station should be designed to withstand (with a factor of safety of 1.4) hydrostatic uplift due to perched ground water. The design-basis perched ground-water contour map identified in Section 2.4.2 of this DCP should be used for the uplift evaluation. If the minimum factor of safety is not achieved in the calculations, the design of the structure should be modified as necessary.

- The permanent lift station should be designed to have a factor of safety of 2.0 against failure resulting from axial and radial wall stresses. The lift station should be evaluated for its adequacy with respect to radial crushing, radial buckling, axial crushing, and axial buckling (design considerations). To satisfy these design criteria, an analysis should be performed to evaluate the effects of lateral earth pressure and potential hydrostatic forces on the structure. The analysis should consider the type of backfill material to be used around the structure and the design-basis perched ground-water level at the location of the structure. If the minimum factor of safety is not achieved in the calculations, the design-basis of the structure should be modified as necessary. Potential modifications include increasing the wall thickness, adding internal or external gussets, and changing the type of backfill to be placed around the structure.

- The permanent lift station should be capable of storing the quantity of leachate generated during an one-week period using design assumptions simulating final closure of the OSDF (OAC 3745-27-08(C)(5)(d)). Potential storm surge flows from an OSDF cell into the permanent EPLTS gravity line due to heavy precipitation into a newly opened cell should be regulated using valving in the EPLTS valve houses or in the control valve house so that the storm design-basis flow rate upon which the permanent lift station pump design is based is not exceeded.

- The permanent lift station should have sufficient pump capacity to prevent the buildup of liquid in the manhole for the storm design-basis flow rate for the leachate transmission gravity line. The lift station should have redundant pump capacity and automatic controls (with manual overrides) for operating the pumps.

- The permanent lift station pumps should be designed to be conveniently removed from the lift station for periodic maintenance. Extra pumps for the permanent lift station should be maintained on the FEMP property for use during periods of pump servicing.

- The permanent lift station should contain pump controls, valves, and mechanical and electrical equipment to achieve the operational objectives described above.

- The Systems Plan for the OSDF should describe the operational and maintenance activities necessary to achieve the operational objectives described above.

- Utilities to the EPLTS valve houses, control valve house, and permanent lift station should meet the design criteria of Section 2.9.2.2 of this document.

- The permanent EPLTS gravity line, EPLTS valve houses, control valve house, and permanent lift station should be constructed as a complete system. Each valve house should be constructed with stub-out sections of leachate collection, redundant leachate collection, and leak detection containment and carrier pipes. The ends of the stub-out pipe sections should be joined to the corresponding pipe sections from each OSDF cell at the time each cell is constructed. Stub-out pipe sections should be capped and protected until such time that the cell connections are made. Also, until such time that the cell connections are made and the new cell becomes active, valves within the valve houses shall be secured in a shut position to prevent leachate backflow from the permanent EPLTS gravity line into the stub-out pipe sections or into the new cell.

B. Calculations

Calculations should be performed to ensure that the leachate transmission system can transmit the required quantity of liquid and store leachate as required by the design criteria. Calculations should include the following:

- The capacity of the permanent EPLTS gravity line should be evaluated using standard pipe capacity calculation methods to ensure that the pipe has sufficient capacity to maintain flow conditions at the required factors of safety under the various design flow conditions.

- The structural stability of the permanent EPLTS gravity line should be evaluated using standard methods for buried flexible pipes.

- The minimum thicknesses of soil cover that must be placed over the permanent EPLTS gravity line for frost protection should be estimated based on the modified Berggren method [Aldrich and Paynter, 1953].

- The hydraulic pressures inside the permanent EPLTS gravity line should be calculated, and it should be demonstrated that the pipes have adequate strengths to handle these pressures.

- The permanent EPLTS gravity line pipe hydrograph should be evaluated to demonstrate the leachate collection system, valve house piping, and EPLTS pipe system will convey the storm design basis flow rate to the permanent lift station.

- The EPLTS valve houses, control valve house, and permanent lift station should be designed to resist hydrostatic uplift with a minimum factor of safety of 1.4. Procedures for calculating the hydrostatic uplift pressures due to high ground water are given in Lambe and Whitman [1969] and Holtz and Kovacs [1981], for example.

- The EPLTS valve houses and control valve house should have the structural concrete designed to provide adequate shear and flexural capacity against earth and building loads using the load and resistance factor design (LRFD) or similar method.
- The elevations of the EPLTS valve house and control valve house should be evaluated for flooding potential based on the 25-year, 24-hour storm.
- The EPLTS valve houses and control valve house should be designed to provide a factor of safety of 1.5 against overturning, sliding, and bearing capacity.
- The EPLTS valve houses and control valve house should be evaluated for differential settlement that would cause grade reversals of the leachate collection system or leak detection system pipes with respect to the cell outlet and loads imposed by the completed OSDF.
- The building electrical service should be evaluated for total load imposed on the overhead distribution systems and equipment should be sized to handle these loads in accordance with the National Electrical Code.
- The EPLTS valve houses and control valve house heating load should be evaluated to provide sufficient heat to prevent freezing of the piping without requiring heat tracing. The calculation should be based on the ASHRAE 99.6 percent minimum temperature and maintenance of 40°F (4°C) inside the building.
- The EPLTS valve houses and control valve house should be evaluated to ensure at least six air changes per hour are provided.
- The pressure head, efficiency, and pumping rate requirements of the pumps that will be installed in the permanent lift station should be evaluated using standard pump design procedures. The pumps for the permanent lift station will be

designed as part of the different design package addressing design of the forcemain from the permanent lift station to the biosurge lagoon.

- The permanent lift station should be designed with sufficient storage volume to safely contain the quantity of leachate generated over a one-week period at the start of the post-closure period. The calculations must demonstrate that the permanent lift station has adequate storage capacity for this flow scenario.

- The permanent lift station should be designed to have a factor of safety of 2.0 against failure resulting from axial and radial wall loads including radial crushing, constrained radial buckling, axial crushing, and axial buckling. Acceptable analysis procedures include, for example: (i) axial buckling as presented in Roark and Young [1982]; (ii) axial crushing as presented in Watkins, Szpak, and Allman [1974]; (iii) radial circumferential crushing as presented in Watkins, Szpak, and Allman [1974]; and (iv) constrained radial buckling as presented in Cagle and Glassock [1975].

2.5.4 Till Monitoring System

A. Criteria

Fluor Fernald, Inc. has prepared a *Project Specific Plan (PSP)* for a *Groundwater Detection Monitoring Program (GDMP)* for the OSDF. A component of the plan involves a till monitoring system consisting of horizontal monitoring wells installed beneath the OSDF liner system at the low point of each OSDF cell. The purpose of the till monitoring system is to provide a capability to detect leakage through the liner system occurring at the low point in the cell. This DCP addresses the physical design of the horizontal monitoring wells associated with the till monitoring system.

The horizontal monitoring wells of the till monitoring system should meet the design criteria given below (design considerations):

- The horizontal monitoring well for a given OSDF cell should be independent of the leachate collection system and leak detection system for that cell.

- The horizontal monitoring well for a given cell should be located vertically below the low point of that cell.

- The horizontal monitoring well should consist of a perforated horizontal pipe in a gravel filled trench. The pipe should be manufactured from HDPE for durability and should have a maximum SDR of 11. The nominal diameter of the well should be at least 6 in. to provide adequate cleanout capability.

- The trench in which the horizontal monitoring well is placed should be designed to resist differential settlement due to different compressibilities of the trench fill and adjacent undisturbed till soil. Differential settlements between the trench backfill and undisturbed till should not induce tensile strains in the compacted clay liner exceeding 0.5 percent. This allowable tensile strain level has been conservatively established based on the available geotechnical literature and information.

- Liquid entering the horizontal monitoring well should flow by gravity to a monitoring point located at the western perimeter of the OSDF.

- Access should be provided at the western perimeter of the OSDF for purging and sampling the horizontal monitoring well. Cleanout access should also be provided.

- The pipe perforations for the horizontal monitoring well should be designed to retain the granular trench backfill that will be used in the perforated zone.

- The geotextile filter layer that will surround the granular trench backfill in the perforated zone should be designed to retain the adjacent native and compacted soils.

B. Calculations

The following calculations should be performed for the horizontal monitoring wells:

- tensile strain induced in the compacted clay liner due to differential compressibility of the granular trench backfill and undisturbed till, using classical geotechnical engineering procedures for calculating total and differential settlements (see for example the references cited in Section 2.3.3 of this DCP);

- horizontal monitoring well structural stability (using standard methods for evaluating the strength and stability of buried flexible pipes);

- required perforation sizing of the horizontal monitoring well (using an analysis based on the granular trench backfill particle size distribution);

- gravity flow capacity of the horizontal monitoring well (using standard pipe flow capacity calculation methods); and

- geotextile filter design, using procedures presented by Giroud [1982] or Christopher and Holtz [1984], or other suitable methods.

2.5.5 References

FEMP property data and information required for design of the leachate management system should be obtained from the references cited in Section 1.5 of this DCP. Additional information for design may be obtained from the general technical references listed below.

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2.6 Final Cover System

2.6.1 General Design Criteria

The final cover system must isolate impacted material in the OSDF, protect the OSDF from inadvertent intrusion, promote vegetative growth, and greatly limit infiltration of precipitation into the facility after closure. The final cover system must also be designed to minimize requirements for long-term monitoring, maintenance, and repair. The components of the final cover system are shown in Figure 1-1 and include (in descending order) topsoil, vegetative soil layer, granular filter layer, biointrusion barrier, cover drainage layer, geotextile cushion, composite cap, and contouring layer.

Closure of the OSDF, which includes installation of the final cover system, must be performed in a manner that minimizes the need for further maintenance and the potential for release of leachate to the environment to the extent needed to protect human health and the environment (ARAR: OAC 3745-27-11(O)). The final cover system requirements must also be designed to be effective for 1,000 years, to the extent reasonable, and in any case, for at least 200 years (ARAR: 40 CFR §192.02(a)). In addition, the final cover system should meet the following OU2 and OU5 ARARs (40 CFR §265.310(a)):

- minimize liquid infiltration into the closed OSDF;
- function with minimal maintenance;
- promote drainage and minimize erosion or abrasion of the cover;
- accommodate settling and subsidence so that the integrity of the cover is maintained; and
- have a permeability less than or equal to the permeability of the liner system or natural subsoils present.

2.6.2 Final Cover Vegetation

A. Design Criteria

As part of closure of the OSDF, vegetation will be planted on the topsoil component of the final cover system. Through time, this vegetation will climax according to a natural succession pattern. The vegetation to be planted should satisfy the design criteria given below.

- The vegetative cover should minimize erosion and off-site sedimentation so that sediment removal structures will not be necessary, (i.e. seed/fertilizer mix should preclude gully initiation) (design consideration).
- The maximum root depth of the vegetative cover should not grow below the vegetative soil layer (design consideration).
- The vegetative cover should not be an attraction to burrowing wildlife, to the greatest extent possible (design consideration).
- The vegetation in drainage channels of the OSDF should be able to withstand temporary inundation (design consideration).
- A low-maintenance, self-sustaining vegetation that is resistant to drought and conforms to the surrounding landscape is desirable.

B. Calculations

The vegetation evaluation should be performed as follows:

- conduct a survey of regional seed sources to identify species availability;
- develop a matrix for locally suitable and available plant species;
- rank suitable species with respect to site conditions, design criteria, and design parameters; and
- develop seed mix designs and associated cultural requirements for establishing seasonal and permanent vegetation for wet, moderate, and dry conditions.

Additional work to establish site-specific soil amendments should be required. Composite soil samples of potential topsoil materials should be analyzed. The results of the analysis should be used to establish lime, fertilizer, and organic material application rates.

2.6.3 Topsoil

A. Design Criteria

A vegetated topsoil layer will form the uppermost component of the OSDF final cover system. The topsoil layer should satisfy the design criteria given below.

- The topsoil layer should be at least 6 in. thick (functional requirement).
- The topsoil layer will have healthy grasses or other vegetation that form a complete and dense vegetative cover (ARAR: OAC 3745-27-08(C)(15)(e)).
- The topsoil layer should promote vegetation that is self-sustaining (design consideration).
- Temporary erosion control of the topsoil layer should be achieved using temporary erosion control matting, if needed, or other suitable methods (design consideration).
- Long-term erosion control of the topsoil layer should be achieved through combination of flat slopes, smooth slope transitions, and use of appropriate soil types and seed/fertilizer mixes that preclude gully initiation (design consideration).
- Topsoil will have a maximum projected erosion rate of 5 tons/acre/year (ARAR: OAC 3745-27-08(C)15)(f)). In addition, the properties of the topsoil and underlying layers should be adequate to result in a cumulative projected volume of eroded material over the design life of the facility that results in sufficient remaining soil thickness to provide freeze-thaw protection of the compacted clay component of the final cover system (design consideration).
- Topsoil and vegetation should resist gully initiation under the tractive forces of surface-water runoff from the cover (design consideration).

B. Calculations

Long-term final cover system erosional resistance should be evaluated as follows:

- obtain the allowable tractive force on the topsoil using methods established by Temple et al. [1987], as described in the DOE Technical Approach Document [1989] and referenced documents;
- establish the actual tractive force on the cover system vegetation and the "effective" tractive force on the topsoil using methods established by Temple et al. [1987], as described in the DOE Technical Approach Document [1989] and referenced documents;
- using the final cover geometry of the OSDF, establish the maximum slope length achievable prior to gully formation using methods described in the U.S. Nuclear Regulatory Commission (NRC) Staff Technical Position: "*Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites*" [NRC, 1990] and referenced documents;
- demonstrate that the OSDF final cover slope length is less than the maximum allowable slope length calculated in the previous step;
- establish peak flow velocity on the final cover system for the design storm recurrence interval using methods established by Temple et al. [1987];
- establish the permissible velocity for the final cover using methods described in NRC Staff Technical Position: "*Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites*" [NRC, 1990] and referenced documents;
- demonstrate that the peak flow velocity does not exceed the permissible velocity; this calculation is performed as a check of the Temple/NRC tractive force method; and
- using the Modified Unified Soil Loss Equation [Nelson et al., 1986], confirm that erosion rate of the topsoil and underlying soil layers: (i) does not exceed 5 tons per acre per year; and (ii) does not (over the (up to) 1,000-year design life of the OSDF) result in an insufficient soil thickness to provide freeze-thaw

protection of the compacted clay layers; the required thickness for freeze-thaw protection should be performed using the modified Berggren method [Aldrich and Paynter, 1953].

The need for temporary erosion control matting should be evaluated using the gully formation analysis described above, assuming a 2-year, 24-hour storm event and bare topsoil.

2.6.4 Vegetative Soil Layer

A. Design Criteria

A vegetative soil layer will underlie the topsoil layer of the OSDF final cover system. Design criteria for the vegetative soil layer are given below.

- The vegetative soil layer should be a well-graded mixture of clayey, silty, and sandy material, at least 21 in. thick (functional requirement).
- The vegetative soil layer should be designed for minimal erosion by wind and water and to preclude the development of gullies (design consideration).
- The vegetative soil layer together with other final cover system layers that overlie the composite cap will have sufficient thickness to protect the composite cap components from damage due to root penetration (ARAR: OAC 3745-27-08(C)(15)(e)).
- The vegetative soil layer should meet the erosion rate criteria given in Section 2.6.3 of this DCP.

B. Calculations

The cover system erosional resistance and frost protection should be evaluated as part of the calculation described in Section 2.6.3 of this DCP.

2.6.5 Granular Filter Layer

A. Design Criteria

A granular filter layer will underlie the vegetative soil layer component of the OSDF final cover system. The filter should comply with the following design criteria.

- The filter layer should be at least 6 in. thick (functional requirement).
- The filter layer should be designed using granular earth materials if possible. If a suitable filter cannot be designed using granular earth materials, then geosynthetic materials may be considered (design consideration).
- The granular filter layer should be designed to prevent migration of soil from the vegetative soil layer through the filter to the biointrusion barrier layer (design consideration).
- The granular filter layer should be continuous over the surface of the biointrusion barrier layer (design consideration).

B. Calculations

Industry standard procedures should be used to establish the particle size requirements of the granular filter layer. Procedures such as those presented in the UMTRA Technical Approach document [1989] or Cedegren [1977], or other appropriate procedures, should be used. If geotextile filters are needed, the procedures of Giroud [1982] or Christopher and Holtz [1984], or other appropriate references, should be applied.

2.6.6 Biointrusion Barrier

A. Design Criteria

A biointrusion barrier layer will underlie the granular filter layer component of the OSDF final cover system. The purpose of this layer is to prevent intrusion of plant roots and burrowing animals into the OSDF. The biointrusion barrier layer should comply with the following design criteria.

- The biointrusion barrier should consist of durable crushed rock or natural stone (possibly with gravel and boulder size fractions) (functional requirement).

- The biointrusion barrier should be at least 3 ft thick (functional requirement).

- The biointrusion barrier should be designed to prevent plant root or animal intrusion into the OSDF (functional requirement).

- To prevent plant root or animal intrusion, the biointrusion barrier should extend at least 40 ft laterally beyond the limit of impacted material disposal in the OSDF. Alternatively, the biointrusion barrier may be terminated in a trench around the perimeter of the OSDF. The bottom elevation of the trench should be no higher than the elevation of the bottom of the adjacent OSDF liner system (design considerations).

- The maximum dimension of the biointrusion barrier material should be no more than one-half of the barrier thickness (i.e., not more than 18 in. for a 3 ft thick barrier thickness) (design consideration).

- The biointrusion barrier material should be free draining (design consideration).

- The upper surface of the biointrusion barrier layer should be "choked off" with material that will provide a filter to the overlying granular filter layer (design consideration).

- The specifications for the choke layer and the biointrusion barrier materials should require a rock quality rating of 50 percent or higher for these materials based on the design procedure for rock selection presented in the UMTRA Technical Approach Document [DOE, 1989] (design consideration).

B. Calculations

The biointrusion barrier should be designed to have rock of sufficient size to deter burrowing animals, yet sufficient void space (excluding the choke layer) to allow rapid drainage of infiltration and to discourage root growth. The guidance in Hakonson [1986] should be used to establish biointrusion barrier attributes to achieve these objectives. Information presented in the UMTRA Technical Approach Document

[DOE, 1989] should be used to evaluate the durability characteristics of the barrier material.

The filter criteria in the UMTRA Technical Approach Document [DOE, 1989], Cedegren [1977], or other suitable criteria, should be used to evaluate required particle size distribution requirements of the choke layer with respect to serving as a filter to the overlying granular filter layer and, in turn, being filtered by the underlying biointrusion barrier layer.

The erosion resistance of the biointrusion barrier should be evaluated using the Stepheson method [Apt et al., 1988], as described in NRC Staff Technical Position: "*Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites*" [1990]. The erosion resistance should be checked using the method established by Hartung and Scheverlein [1970].

2.6.7 Cover Drainage Layer

A. Design Criteria

A cover drainage layer will underlie the biointrusion barrier component of the OSDF final cover system. In turn, this layer is required to overlie the geomembrane cap component of the OSDF final cover system (ARAR: OAC 3745-27-08(C)(15)(a)). (Note: A geotextile cushion layer may be placed between the cover drainage layer and geomembrane cap without violating this ARAR.) The cover drainage layer should satisfy the following design criteria.

- The drainage layer will consist of a 12 in. thickness of granular material, with the layer meeting the requirements of OAC 3745-27-08(C)(4)(a) (ARAR: OAC 3745-27-08(C)(16)(b)(i)). Alternatively, the drainage layer may consist of a geonet that has equivalent performance capabilities to a granular material satisfying the requirements of OAC 3745-27-08(C)(4)(a) (ARAR: OAC 3745-27-08(C)(16)(b)(ii)). To maximize the service life of the OSDF final cover system, a granular drainage layer is preferred over a geonet drainage layer.

- The drainage layer should limit the buildup of hydraulic head on the geomembrane cap to not more than 1 ft, or to the thickness of the drainage layer, whichever is less (design consideration).

- The drainage layer should be designed to rapidly convey infiltrating liquid off of the OSDF final cover system (design consideration).

B. Calculations

Final cover system infiltration potential should be evaluated as part of an analysis of the final cover system water balance using the USEPA HELP model, Version 3, [Schroeder, 1994a,b] or other appropriate method. The calculation should be performed, assuming representative properties for the cover system components.

The hydraulic head buildup in the cover drainage layer should also be evaluated using the USEPA HELP model. The procedure presented in Giroud and Houlihan [1995] should be used to confirm the HELP model results. The calculations should evaluate both the maximum and average head buildup conditions under the design storm event. The maximum head should be compared to the thickness of the drainage layer to confirm that the layer thickness is greater than the maximum head and that the maximum head is less than 1 ft. The average hydraulic head should be used in calculations to evaluate the slope stability factor of safety of the final cover system.

2.6.8 Geotextile Cushion Layer

A. Design Criteria

A geotextile cushion layer will be installed above the geomembrane cap component of the OSDF final cover system to protect the geomembrane from puncture by particles in the overlying cover drainage layer (design consideration). The geotextile should also be robust enough to resist the effects of construction (i.e., termed construction survivability) (design consideration).

B. Calculations

The design of the geotextile cushion layer to provide adequate puncture protection for the geomembrane cap should be performed using the procedure described by Koerner et al. [1995]. If this method is used, the minimum acceptable factor of safety against puncture is 3.0. The calculation for evaluating geotextile cushion requirements should consider two loading conditions: (i) short-term case assuming that construction equipment is working above the drainage layer material; and (ii) long-term case assuming the final cover system is installed. The design of the geotextile cushion layer to have adequate construction survivability should be performed using the procedure described in Koerner [1994].

2.6.9 Composite Cap

A. Design Criteria

The functional requirements (Appendix B) for the OSDF call for the OSDF final cover system to contain three low-permeability infiltration barrier layers designed to isolate impacted material from the surrounding environment while minimizing liquid infiltration into the OSDF. These three layers are, from top to bottom (Figure 1-1):

- 60-mil (minimum) thick geomembrane cap;
- geosynthetic clay cap; and
- 2-ft thick compacted clay cap.

Taken together, these three layers are called the "composite cap". Design criteria for the composite cap are as follows:

- The composite cap will overlie all areas where impacted material has been placed (ARAR: OAC 3745-27-08(C)(15)).
- The composite cap will have a permeability less than or equal to the permeability of the liner system (ARAR: 40 CFR §265.310).
- The compacted clay component of the composite cap will have a minimum thickness of 18 in. and a maximum hydraulic conductivity of 1×10^{-6} cm/s (ARAR: OAC 3745-27-08(C)(15)(ii)). The functional requirements in Appendix B of this DCP require that the compacted clay component of the composite cap be at least 24 in. thick. The *Final Feasibility Study Report for Operable Unit 2* [DOE, 1995b] requires that the hydraulic conductivity of the compacted clay cap be no larger than 1×10^{-7} cm/s. In addition, the compacted clay cap must satisfy the requirements of OAC 3745-27-08(C)(1)(a) to (C)(1)(g) and (C)(1)(m) to (C)(1)(o) (ARAR: OAC 3745-27-08(C)(16)(a)(ii)).

- The HDPE geomembrane component of the composite cap will have a minimum thickness of 60 mil, be negligibly permeable to fluid migration, and satisfy the other requirements of OAC 3745-27-08(C)(2) (ARAR: OAC 3745-27-08(C)(16)(a)(ii)).

- The composite cap will be constructed at a slope between 5 and 25 percent (ARAR: OAC 3745-27-08(C)(15)(f)(ii)). A flatter maximum slope should be used if necessary to achieve required slope stability factors of safety (design consideration).

- Any penetrations through the composite cap system will be sealed so that the integrity of the compacted clay component of the cap is maintained (ARAR: OAC 3745-27-08(C)(15)).

- The geosynthetic clay cap component of the composite cap should have a hydraulic conductivity of no greater than 5×10^{-9} cm/s under the applicable normal stress (design consideration).

- In addition to the foregoing, the geosynthetic clay cap should be of the "internally-reinforced" type. This type of geosynthetic clay cap will improve short-term cover system stability compared to the level of stability achieved with an "unreinforced" type geosynthetic clay cap. The benefits of geosynthetic clay cap internal reinforcement or partial hydration should be discounted in evaluating the long-term stability of the final cover system (i.e., the geosynthetic clay cap should be considered unreinforced and fully hydrated for long-term stability analyses) (design considerations).

- The geosynthetic clay cap should be designed to prevent failure due to long-term creep down the cover system sideslopes (design consideration).

B. Calculations

As part of the design of the OSDF final cover system, an evaluation should be performed to establish whether a textured geomembrane, manufactured of HDPE, and of 60-mil minimum thickness, is the most appropriate type of geomembrane (in terms of composition, thickness, surface texturing, etc.) for use on the project. The design of the OSDF final cover system should also include further evaluation of the most appropriate type of geosynthetic clay cap to use on this project.

2.6.10 References

FEMP property data and information required to design the OSDF final cover system should be obtained from the references cited in Section 1.5 of this DCP. References from the general technical literature that may be used in the design of the final cover system are given below.

Aldrich, H.P. and Paynter, H.M., "Frost Investigations, Fiscal Year 1953, First Interim Report," *Analytical Studies of Freezing and Thawing Soils*, Arctic Construction and Frost Effects Laboratory, New England Division, U.S. Arm Corps of Engineers, Boston, MA, 1953.

Abt, S.R., Wittler, R.J., Ruff, J.F., LaGrone, D.L., Khattak, M.S., Nelson, J.D., Hinkle, N.E., and Lee, D.W., "*Development of Riprap Design Criteria by Riprap Testing In Flumes: Phase II - Followup Investigations*", NUREG/CR-4651-V2 ORNL/TM-10100/V2, U.S. Nuclear Regulatory Commission, Washington, D.C., September 1988, 84 p. (plus appendices).

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Christopher, B.R. and Holtz, R.D., "*Geotextile Engineering Manual*", FHWA-DTFH61-80-C-00094, U.S. Department of Transportation, Federal Highway Administration, 1984.

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Koerner, R.M., "*Designing with Geosynthetics*", Third Edition, Prentice Hall, Englewood Cliffs, NJ, 1994, 783 p.

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Schroeder, P.R., Aziz, N.M., Lloyd, C.M., and Zappi, P.A., "*The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3*", EPA/600/R-94/168a, U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C., 1994a.

Schroeder, P.R., Dozier, T.S., Zappi, P.A., McEnroe, B.M., Sjostrom, J.W., and Peyton, R.L., "*The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3*", EPA/600/R-94/168b, U.S. Environmental Protection Agency, Office of Research and Development, Washington D.C., 1994b.

Temple, D.M., Robinson, K.M., Ahring, R.M., and Davis, A.G., *Stability Design of Grass-Lined Open Channels*, United States Department of Agriculture, Agriculture Handbook No. 667, Sept. 1987, 167 p.

U.S. Department of Energy (DOE), "*Technical Approach Document, Revision II*", (Uranium Mill Tailings Remedial Action Project, December 1989.

U.S. Department of Energy (DOE), "*Final Feasibility Study Report for Operable Unit 2*, Fernald Environmental Management Project", DOE Fernald Area Office, Fernald, OH, 1995b.

U.S. Nuclear Regulatory Commission (NRC), *Staff Technical Position: "Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites*", 1990.

2.7 Test Pad Program

2.7.1 General Design Requirements

The function of the test pad program is to confirm the hydraulic conductivity characteristics of the soil that will be used to construct the compacted clay liner and cap components of the OSDF. Information obtained during the test pad program will be used to qualify the site-specific clay borrow source(s) and define construction procedures for the compacted clay liner and cap materials.

To demonstrate that the clay from each borrow source (presently anticipated to include both the OSDF foundation excavation and the on-site borrow area) can meet the criteria for clay liner and cap materials and construction methods, the test pad program should establish that (design considerations):

- the clay material can be compacted under the anticipated construction conditions to an in-place hydraulic conductivity not greater than 1×10^{-7} cm/s; and
- on-site sources exist for clay borrow materials that meet the other design criteria for clay liner and cap material (see Section 2.4.5 of this DCP).

Also, to meet the requirements of OAC 3745-27-08(C)(1)(m), the test pad program will:

- be designed such that the proposed tests are appropriate and their results are valid ((1)(m)(i));
- be designed to establish construction procedures that result in a clay liner or cap with satisfactory hydraulic conductivity; the construction procedures include:
  - lift thickness;
  - compaction moisture content and density; and
  - type, weight, and number of passes of construction equipment ((1)(m)(ii)); and

- be completed prior to construction of the disposal facility component which the test pad will model ((1)(m)(iii)).

The test pad program should also be designed to establish on-site borrow material processing requirements. Lastly, construction procedures for the clay liner and cap test pad program should be in general accordance with industry established guidelines, such as those in USEPA [1989, 1993].

2.7.2 Clay Borrow Material Criteria

The clay material used in the test pad program should be obtained from the same sources as the clay material that will be used in the OSDF construction project. The clay material will satisfy the following material property requirements (ARAR: OAC 3745-27-08(C)(1)(c)):

- 100 percent of the particles must have a maximum dimension not greater than 2 in.;
- not more than 10 percent of the particles, by weight, must have a dimension greater than 0.75 in.;
- at least 50 percent of the particles, by weight, must pass through the U.S. No. 200 standard sieve; and
- at least 25 percent of the particles, by weight, must have a maximum dimension less than 0.002 mm.

As described in Section 2.4.5 of this DCP, available borrow at the site may not, in all cases, meet the requirement to have 25 percent of the particles, by weight, smaller than 0.002 mm. The available borrow also may not, in all cases, meet the requirement to have at least 50 percent of the particles, by weight, pass a U.S. No. 200 standard sieve. A demonstration will need to be submitted to USEPA and OEPA pursuant to OAC 3745-27-08(C)(1) to obtain acceptance of the on-site borrow materials. The test pad program will be an integral part of that demonstration.

2.7.3 Test Pad Layout and Construction Criteria

The test pads should be constructed at one or more locations within the battery limit that meet the following criteria:

- The test pad should be located in an area where the soil conditions are similar to the subgrade conditions that will be encountered in the OSDF construction area (design consideration).
- The test pad should be located in an area acceptable to Fluor Fernald, Inc. based on existing conditions with respect to the presence of impacted surficial soil and any plan for removal of such soil (design consideration).
- The location for the test pad should be selected considering ease of access for construction vehicles, presence of perched ground water, surface-water management, etc. (design consideration).

The test pad construction program should adhere to the following basic procedures (design considerations):

- Prior to the start of construction, surface-water management and erosion and sediment controls should be established, and clearing and grubbing should be performed.
- Soils for test pad construction should be obtained from the identified on-site borrow source(s).
- The test pads should be constructed using 8-in. thick loose lifts, with a maximum clod size of 3 in. or half of the compacted lift thickness, whichever is less.
- The test pads should be constructed using varying number of passes of compaction equipment and specified ranges of moisture content so that a relationship can be established between compaction effort, moisture content, and hydraulic conductivity.
- The target compaction criteria should be established prior to the start of test pad construction. The criteria should be based on the results of pre-construction laboratory testing of samples of the soils to be used to construct the test pads.

The target compaction dry density should be at least 95 percent of the maximum standard Proctor dry unit weight according to test method ASTM D 698; target moisture contents should be between the optimum moisture content and 4 to 5 percentage points wet of the optimum moisture content.

- Specific equipment requirements should be identified for moisture conditioning, clod breakdown, and compaction before the start of the test pad construction project.
- Once constructed, in-situ testing techniques should be used to establish the field hydraulic conductivity of each test pad.
- After testing is complete, the test pad should be decommissioned.

To meet the requirements of OAC 3745-27-08(C)(1), the test pad will:

- be constructed whenever, during OSDF construction, there is a significant change in soil material properties ((1)(m)(iv));
- have a minimum width three times the width of the compaction equipment and a minimum length two times the length of compaction equipment, including any attachments ((1)(m)(v));
- be comprised of at least four lifts; for each lift a minimum of 3 tests for moisture content and density must be performed ((1)(m)(vi));
- be tested for field permeability, following the completion of test pad construction ((1)(m)(vii)); and
- be reconstructed as many times as necessary to meet the permeability requirement ((1)(m)(viii)).

To meet all of the foregoing requirements, it is anticipated that at least two test pads will need to be constructed to account for different potential borrow source characteristics. It is also anticipated that each test pad will contain several lanes, with soil moisture conditions and compaction criteria differing between lanes. For economy, the test pads should be constructed at one time. Testing of the pads may be performed sequentially or in parallel depending on the project schedule and availability of field test equipment.

2.7.4 Field Test Pad Program Evaluation

The test pad program should involve both pre-construction and construction-phase testing of clay liner and cap materials.

Pre-Construction Testing Program

Pre-construction laboratory testing should be performed on the material that will be used for test pad construction to establish the soil compaction conditions that will be used in test pad construction (design consideration). The steps that should be included in the pre-construction testing program are given below (design considerations).

- Step 1. Perform soil index testing of materials from the borrow sources; at a minimum soil index testing should include natural moisture content (ASTM D 2216), particle size distribution (ASTM D 422), Atterberg limits (ASTM D 4318), and soil classification (ASTM D 2487).

- Step 2. Establish soil moisture-density relationships for several different compactive efforts.

- Step 3. Perform soil hydraulic conductivity testing to evaluate hydraulic conductivity as a function of compaction moisture content and dry density. Hydraulic conductivity testing should be performed in accordance with ASTM D 5084.

- Step 4. Based on the results of Steps 2 and 3, select field target compaction conditions (i.e., acceptable range of moisture contents and dry densities), to be used for each lane of the test pad. Procedures as described by Daniel and Benson [1990] may be used for guidance in establishing moisture-density criteria.

Construction-Phase Testing Program

Field and laboratory testing should be performed during and after test pad construction to verify the adequacy of the construction materials and methods (design consideration). Testing should include (design considerations):

- field moisture content and dry density of each lift of the test pad using a nuclear gauge (ASTM D 2922 and D 3017), periodically checked using a sand cone test (ASTM D 4914) or drive cylinder test (ASTM D 2937) and oven moisture content test;
- laboratory confirmatory standard Proctor compaction testing (ASTM D 698);
- laboratory hydraulic conductivity testing using a flexible wall permeameter (ASTM D 5084) and undisturbed specimens of compacted material obtained using a thin-walled Shelby tube; and
- field sealed double-ring infiltrometer (SDRI) testing of each completed test pad (ASTM D 3385).

2.7.5 Work Plan

A work plan should be prepared to describe the proposed test pad program (functional requirement). The work plan should include drawings showing the test pad layout, typical sections, surface-water management plan, and specifications for construction of the test pad (design consideration). The work plan should also include the basis for test pad design, requirements for laboratory and field testing, and requirements for construction quality assurance (CQA) monitoring and documentation (design consideration). The test pad work plan should first be prepared at the prefinal (90%) level of completeness for submittal for review by DOE, USEPA, and OEPA. A final work plan should be issued after incorporation of review comments.

2.7.6 Cost Estimate

A test pad program cost estimate should be prepared based on the prefinal test pad program work plan (functional requirement). The cost estimate must be in Fluor Fernald, Inc. format (functional requirement). This format is illustrated by the Fluor Fernald, Inc. baseline OSDF cost estimate presented in Appendix E of this document.

2.7.7 Report

The results of the test pad program should be analyzed and a report prepared to present the program results (functional requirement). The report should contain: (i) recommendations regarding the suitability of the borrow sources for use as clay liner and cap material; (ii) requirements for borrow source processing; and (iii) recommended criteria for clay liner and cap construction (design consideration).

2.7.8 Schedule

The final test pad work plan must be completed prior to the completion of the OSDF intermediate design package (functional requirement). The test pad program final report must be completed prior to completion of the OSDF final design package (functional requirement).

2.7.9 References

FEMP property data and information required to develop the test pad program should be obtained from the references cited in Section 1.5 of this DCP. References from the general technical literature that may be used to develop the test pad program are given below.

Daniel, D.E. and Benson, C.H., "Water Content-Density Criteria for Compacted Soil Liners", *ASCE Journal of Geotechnical Engineering*, 1990, Vol. 116, No. 12, 1990, pp. 1811-1830.

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2.8 Surface-Water Management

2.8.1 Categories of Surface Water

Surface-water management for the OSDF must consider three categories of surface water:

- surface-water runon from outside the battery limit to within the battery limit;
- surface-water runoff, which includes all runoff from disturbed areas within the battery limit, except for wastewater explicitly identified below; and
- wastewater, which includes all waters that must be contained, collected, and conveyed to the biosurge lagoon or the FEMP former production area storm drainage control system.

Wastewater generated as a result of development of the OSDF area includes:

- leachate and runoff from impacted material within the OSDF; these wastewaters will be contained in the OSDF, allowed to percolate into the leachate collection system, and then conveyed by gravity through the leachate collection system pipe to the OSDF EPLTS (as discussed in Section 2.5 of this DCP). Surface-water collected in the OSDF cell catchment area may be conveyed to the FEMP former production area storm drainage control system or other on-site wastewater collection/conveyance point acceptable to DOE and OEPA/USEPA.
- runoff from impacted-material staging areas; these are self-contained units; liquid generated in these units will be conveyed to the FEMP former production area storm drainage control system, or other on-site wastewater collection/conveyance point acceptable to DOE and OEPA/USEPA;
- runoff from impacted-material haul roads; this water will be contained, collected, and conveyed to the FEMP former production area storm drainage control system, or other on-site wastewater collection/conveyance point acceptable to DOE and OEPA/USEPA; and
- perched ground water that seeps into excavations; this water will be contained, collected, and conveyed to the FEMP former production area storm drainage

control system, or other on-site wastewater collection/conveyance point acceptable to DOE and OEPA/USEPA.

The remainder of this section of the DCP presents design criteria for management of stormwaters and wastewaters.

2.8.2 General Design Criteria

The functions of the surface-water management system are to: (i) route surface water to designated locations where it can be appropriately managed; (ii) protect the OSDF from damage caused by precipitation and surface-water runon and runoff; and (iii) discharge surface water to existing watercourses in accordance with applicable regulatory and DOE requirements.

The surface-water management system should perform in a manner that meets the project requirements for both temporary conditions (i.e., during construction, filling, and closure of the OSDF) and long-term conditions (i.e., after closure of the OSDF). The system should prevent surface-water runon to the OSDF and uncontrolled stormwater and wastewater runoff from the OSDF. Features of the permanent surface-water management system should be designed to require minimal monitoring and maintenance. The system should be integrated, to the extent possible, with existing topography, features, and facilities (design considerations).

2.8.3 Surface-Water Management During OSDF Construction/Filling/Closure

A. Design Criteria

- Temporary surface-water control structures for the OSDF will be designed for the 25-year, 24-hour storm event (ARAR: EPA 40 CFR §258.26 and OAC 3745-27-08(C)(6)(a) and (b)). For the FEMP property, this event has a rainfall intensity of 4.7 in. [Parsons, 1995a].
- Temporary surface-water control structures will be designed to minimize silting and scouring (ARAR: OAC 3745-27-08(C)(6)(c)).
- Temporary runon control measures should meet the following criteria (design considerations).

- Upgradient runon should be prevented from entering active working areas. Such runon should be diverted around work areas using berms, dikes, or channels as appropriate. This runon should not be allowed to mix with wastewater.
- Runon to temporary excavations should be prevented using berms, ditches, or other surface-water control features.
- Runon to impacted material stockpiles should be prevented using berms, ditches, or other surface-water control features.
- Prior to placement of impacted material into an OSDF cell, permanent runon controls must be in place. The requirements for permanent runon control are described in more detail in Section 2.8.4 of this DCP.

- Runoff from disturbed areas should be routed to the appropriate temporary sediment basin or managed using other appropriate erosion control practices. There must be no mixing of surface-water runoff and wastewaters (functional requirements).
- Temporary sediment basins will meet the following criteria of OEPA (ARAR: OAC 3745-27-08(C)(6)(d)):
  - the minimum acceptable basin storage will be established as the larger of the calculated runoff volume from a 10-year, 24-hour storm event, or, 0.125 acre-ft per year (for each acre) of upgradient disturbed area multiplied by the scheduled frequency of basin cleanout (in years) ((6)(d)(i)); for the FEMP property, the 10-year, 24-hour storm event has a rainfall intensity of 4.1 in. [Parsons, 1995a];
  - the principal spillway will be capable of safely discharging the flow from a 10-year, 24-hour storm event; the inlet elevation of the emergency spillway will be designed to provide flood storage, with no flow entering the emergency spillway during a 25-year, 24-hour storm event, with allowance provided for the flow passed by the principal spillway during the event ((6)(d)(ii)); as previously noted, for the FEMP property, the 25-year, 24-hour storm event has a rainfall intensity of 4.7 in. [Parsons, 1995a];

- the combination of principal and emergency spillways should be capable of safely discharging the flow from a 100-year, 24-hour storm event; the basin embankment design should provide for no less than 1 ft of net freeboard when flow is at the design depth, after allowance for embankment settlement ((6)(d)(iii)); for the FEMP property, the 100-year, 24-hour storm event has a rainfall intensity of 5.6 in. [Parsons, 1995a];

- the basin will be constructed using a compacted soil liner, a geomembrane, or a combination thereof ((6)(d)(iv)); and

- sediment basins will be equipped with ring buoys and other safety/drowning equipment in accordance with USOSHA 1926.106.

- With respect to the last ARAR ((6)(d)(iv)), on 24 February 1992, the OEPA DSIWM issued the following guidance on the need for lining sediment basins:

  "The sole purpose of a liner in a sediment basin is water retention. Therefore, a design capable of ponding water, whether or not it contains a liner, will be acceptable to the Director. In areas with predominantly in-situ low permeability clay, a liner may be unnecessary (it would be wise to scarify and recompact the clay surface). The landfill engineer is responsible for meeting the "ponding" standard. In areas with more permeable soils a recompacted clay liner is necessary, but the QA/QC standards can be minimal and certainly do not need to follow the landfill liner standards."

  The foregoing requirement is interpreted as allowing the development of unlined sediment basins in the low-permeability tills underlying the FEMP. To assure compliance with the intent of this guidance, the construction specifications for sediment basins associated with the OSDF should require scarification and recompaction of the till exposed in the sediment basin excavation, and overexcavation of any observed granular soil zones, followed by backfilling with till and recompaction (design consideration).

- Surface-water runoff from the FEMP watersheds to the receiving water course (e.g., Paddys Run) should be discharged at a rate no greater than the predevelopment runoff discharge rate [ODNR, 1996] (design consideration).

- Temporary channels for stormwater runoff should be designed to meet the following criteria (design considerations).

  - Channel lining:
    - peak flow velocity in riprap-lined channels should be less than 12 ft per second, unless it is demonstrated that greater velocities will not cause erosion or malfunction of the surface-water management feature; and
    - peak flow velocities in grass-lined channels should be less than 5 ft per second.
  - Channel sideslopes should be no steeper than 3 horizontal to 1 vertical.

  - Channel bottom widths may be zero.

  - The channel freeboard should be at least 0.5 ft under the design storm event.

  - Channels should be sloped at no less than 0.5 percent to prevent sediment buildup and clogging, unless it can be established by calculation that a lesser slope will not clog or build up sediment that will cause loss of flow capacity in the design storm event. Channel slopes should be no steeper than 5 percent unless it can be established by calculation that a steeper slope will not cause unacceptable erosion or other malfunction.

- Temporary culverts should be designed according to the following criteria (design considerations).

  - Culverts may be used in locations as needed and where cost-effective.

  - Channels should be protected from erosion using riprap or erosion mats for a length of at least two culvert diameters upstream and a width of at least three culvert diameters of the culvert inlet. The length and width, of riprap lining and average particle size downstream of the culvert outlet should meet criteria for permanent outlet protection provided in USDA-SCS, 1987.

  - Minimum thickness of riprap lining will be two times D_{50}, but not less than 6 in. and will be underlain by geotextile filters.

- Riprap will be designed according to the following criteria (design considerations).

- For channel lining, riprap should be sized to meet the following criteria [ODNR, 1996];

  - $D_{50} = 62.4$ pcf × d × S/4
    where: D_{50} = theoretical spherical diameter of average stone size; d = peak flow depth for the design storm event (ft); and S = channel slope (rise/run).

- Riprap should meet the following particle size criteria [ODNR, 1996]:

  - $D_{max} = 1.5 \times D_{50}$
  - $D_{15} = 0.5$ to $0.75 \times D_{50}$
    where: D_{max} = theoretical spherical diameter of largest stone size; and D_{15} = theoretical spherical diameter of the stone size for which 15 percent of the material is smaller.

- For channels, the minimum thickness of the riprap lining should be two times D_{50}, but not less than 6 in.

- Riprap used at channel transitions should extend upstream and downstream of the transition a distance of five times the downstream channel depth; the minimum extension should be 15 ft.

- Geotextile filters may be used to control piping and erosion beneath riprap in temporary facilities. Granular soils should be used for filters in permanent structures containing riprap, if required to prevent undermining of the riprap.

- Rock, grade control structures should be designed according to the following criteria (design considerations).

  - Rock, grade control structures may be used in temporary facilities. They should be designed in accordance with standard design procedures.

  - The minimum height of rock, grade control structures should be 1.5 ft and the minimum top width should be 2 ft.

- Temporary erosion control measures should include the items listed below (design considerations).

- Runoff from all disturbed areas should be routed to sediment basins, or managed using other appropriate sediment control practices, prior to discharge to natural watercourses, except for wastewaters which should be managed as described in Section 2.8.5 of this DCP.

- The size of any excavated or disturbed area should be as small as possible to minimize the potential for erosion (design consideration). Disturbed areas should be revegetated at the earliest possible time.

- Temporary erosion control may be achieved using geosynthetic materials, vegetation, crusting agents, check dams, straw bales, silt fences, or other appropriate structures.

- The use of erosion control materials should be minimized in impacted soils requiring OSDF disposal. Preference should be given to runon control, surface grading, and the selective use of erosion resistant impacted materials to control erosion of impacted areas.

- Maintenance and upkeep procedures for temporary erosion control features should be specified in the *Surface-Water Management and Erosion Control Plan.*

It is noted that surface-water routing and surface-water management system design for watercourses and structures beyond the battery limit will be addressed in other design packages being prepared as part of the integrated FEMP remediation.

B. Calculations

Calculations should be performed to size the sediment basins for each contributory drainage area for each representative phase of the OSDF development. The calculations should be performed as described below.

- The amount of surface-water runon and runoff should be calculated for each contributory drainage area.

- The size of the drainage control structures (e.g., channels) should be calculated for each contributory drainage area.

- The size of the sediment basin, including outlet structures, should be calculated for each contributory drainage area.

The above calculations should be performed using the design storm events previously identified. Runon/Runoff routing and sediment basin sizing may be evaluated using the procedures described in USDA-SCS Technical Releases 20 and/or 55 [USDA-SCS, 1975, 1986a]; an acceptable tool for performing these calculations is the computer program "*HydroCAD™ Stormwater Modeling System*" [Applied Microcomputer Systems, 1993]. The above evaluations should be based on the information and guidance contained in USDA-SCS manuals [1985, 1986b, and 1988] and ODNR [1996].

Culverts should be sized in accordance with U.S. Federal Highway Administration guidelines [USDOT, 1985] and meet the structural design criteria contained in applicable design references such as the Concrete Pipe Design Manual [America Concrete Pipe Association, 1970].

In the event that a channel bottom grade is less than 0.5 percent, an analysis should be performed to establish that the channel does not clog or build up sediment that will cause loss of flow capacity in the design storm event.

2.8.4 Surface-Water Management After OSDF Closure

A. Design Criteria

- Permanent runon control structures for the OSDF will be designed to limit interruption and damage (i.e., washout) of the OSDF in the 2,000-year, 24-hour storm event (design criterion for assumption of a DOE Performance Category 2 facility). For the FEMP property, this event has a rainfall intensity of 13.0 in. [Parsons, 1995a]. Runon should be controlled and diverted away from and around the OSDF using channels or diversion berms (design consideration).

- Permanent runoff control structures for the OSDF will be designed to limit interruption and damage (i.e., washout) of the OSDF in the 2,000-year, 24-hour storm event (design criterion for assumption of a DOE Performance Category 2 facility).

- Permanent runoff control measures should be designed according to the following criteria (design considerations).
    - Runoff from the 2,000-year, 24-hour storm event should be allowed to sheet flow to the toe of the OSDF final cover.
    - Runoff from the toe of the OSDF final cover should either sheet flow away from the facility or to a drainage channel beyond the toe.
    - Any drainage channels beyond the OSDF final cover system toe should outlet to existing drainage features at the battery limit. The location of the outlets should progress from north to south concurrent with the progressive development of the OSDF. The final outlet location for runoff from the eastern portions of the OSDF should be immediately south of the southern limit of the OSDF.
- Permanent drainage channels will be designed to meet the following criteria (design considerations).
    - The dimensions of the channel should accommodate both normal low flows and peak precipitation runoff flows.
    - The final grades of the channel should be no less than 0.5 percent to prevent sediment buildup and clogging, unless it can be established by calculation that a lesser slope will not clog or buildup sediment that will cause loss of flow capacity in the design storm event. Channel slopes should be no steeper than 5 percent unless it can be established by calculation that a steeper slope will not cause unacceptable erosion or other malfunction.
    - Peak flow velocity in the channel should not initiate channel gully erosion or scour.
    - Erosion potential should be minimized at channel transitions by utilizing smooth, rounded, and graded transitions wherever possible (preferred) and erosion control structures only when needed.
    - Flow velocity in the channel during high frequency (e.g., 2-year return frequency) and low-intensity (i.e., approximately 1 in. in 24 hours) storm

events should be large enough to limit sedimentation in the channels, to the extent possible.

- Channel sideslopes should be no steeper than 3 horizontal to 1 vertical.
- The freeboard in the drainage channel should be at least 0.5 ft during the design storm event.

- Permanent drop inlets and culverts may be used downgradient of the OSDF if necessary and if failure of the drop inlet and culvert would not result in damage to, or interruption of, the OSDF. Permanent drop inlets and culverts should be designed to meet the following criteria (design considerations).

  - Culverts beneath roads or access corridors where traffic is limited to highway vehicles should be designed for American Association of State Highway and Transportation Officials (AASHTO) HS-20 live loads and applicable dead loads.
  - Culverts beneath haul roads or access roads used for construction traffic should be designed for vehicle live loads and applicable dead loads.
  - Channels should be protected from erosion using riprap for a length of at least two culvert diameters upstream and a width of at least three culvert diameters upstream and downstream of the culvert inlet. The length and thickness of riprap lining and average particle size downstream of the culvert outlet should meet criteria for outlet protection provided in ODNR.
  - Permanent culverts should not be used upgradient of the OSDF.

- Riprap, if needed, should be designed as described in Section 2.8.3 of this DCP (design consideration).

- Riprap should consist of field stone or rough unhewn quarry stone of approximately rectangular shape. The stone should be hard and angular and of a good quality, consistent with the UMTRA Technical Approach Document [DOE, 1989] (design consideration).

- Granular soils should be used as filters and bedding for permanent riprap features where necessary to prevent undermining of the riprap (design consideration).

- Rock grade control structures, if used, should be designed to meet the criteria listed in Section 2.8.3 of this DCP (design consideration).

- Surface-water runoff from watersheds in the FEMP to the receiving water course (e.g., Paddys Run) should be discharged at a rate no greater than the predevelopment runoff discharge rate [ODNR, 1996] (design consideration).

It is noted that surface-water routing and surface-water management system design for watercourses and structures beyond the battery limit will be addressed in other design packages being prepared as part of the integrated FEMP remediation.

B. Calculations

Calculations should be performed to size the drainage channels for each contributory drainage area. For these areas where a permanent drainage channel is not needed, the amount of surface-water runoff should be calculated. The calculations that should be performed are described below.

- The amount of surface-water runon and runoff should be calculated for each contributory drainage area.

- The size of the permanent drainage channel should be calculated for each contributory drainage area.

The above calculations should be performed using the design storm events previously identified. Runon/runoff routing and sediment basin sizing may be evaluated using the procedures described in USDA-SCS Technical Releases 20 and 55 [USDA-SCS, 1975, 1986a]; an acceptable tool for performing these calculation is the computer program "*HydroCAD^{TM} Stormwater Modeling System*" [Applied Microcomputer System, 1993]. The above evaluations should be based on information and guidance contained in USDA-SCS manuals [1985,1986b,1988].

In the event that a channel bottom grade is less than 0.5 percent, an analysis should be performed to establish that the channel does not clog or build up sediment that will cause loss of flow capacity in the design storm event.

The erosion resistance of the permanent drainage channel at the north and east toes of the OSDF should be evaluated as follows:

- obtain the allowable tractive force on the channel vegetation and topsoil using methods established by Temple et al. [1987], as described in the DOE Technical Approach Document [1989] and referenced documents;
- establish the actual tractive force on the channel vegetation and the "effective" tractive force on the channel topsoil using methods established by Temple et al. [1987], as described in the DOE Technical Approach Document [1989] and referenced documents;
- determine the potential for erosion of the drainage channel by comparing the allowable tractive force on the topsoil to the "effective" actual tractive force on the topsoil; and
- evaluate the potential for the riprap portion of the channel lining to erode using the Safety Factors Method as described in the DOE Technical Approach Document [1989] and referenced documents.

2.8.5 Wastewater Management

Wastewaters that will be encountered in development of the OSDF were identified in Section 2.8.1 of this DCP. These wastewaters should be managed as follows.

- *Leachate* - Liquid that has percolated through, or been released from, the impacted material that has been disposed in the OSDF (functional requirement). Placement of impacted material in OSDF cells will be performed such that runoff from active and open portions of a cell resulting from the 25-year, 24-hour storm event can be managed within the cell (ARAR: EPA 40 CFR §258.26 and OAC 3745-27-08(C)(6)(a)). Leachate should be managed as described in Section 2.5 of this DCP.
- *Impacted Runoff* – Liquid that comes in contact with impacted material and runs off rather than percolating. Impacted runoff collected in the cell catchment areas may be conveyed as described in this Section. An OMTA will be constructed for the staging of impacted material for subsequent disposal in the

OSDF. To the extent possible, runoff from these OMTA areas should drain to surface-water control structures within the former production area storm drainage control system (design consideration). Runoff from any staging area located within the OSDF battery limit should also be directed to the FEMP former production area storm drainage control system if possible, or to other on-site wastewater collection/conveyance points (if necessary) acceptable to DOE and OEPA/USEPA (design consideration). Additional discussion of the OMTA is presented in Section 2.11 of this DCP. Runoff from impacted material haul roads should be contained within the haul road boundary and allowed to flow by gravity to the FEMP former production area storm drainage control system, or to other on-site wastewater collection/conveyance points (if necessary) acceptable to DOE and USEPA/OEPA. Drainage control structure for impacted material haul roads should be designed for the 25-year, 24-hour storm event. (design consideration).

- *Perched Ground Water* - Perched ground water that enters the OSDF excavation should be collected in a toe drain, or other suitable sump, and pumped to the FEMP former production area storm drainage control system (including pumpage to the impacted-material haul road, where the water will be allowed to flow by gravity to the FEMP former production area storm drainage control system), or to other on-site wastewater collection/conveyance points (if necessary) acceptable to DOE and OEPA/USEPA (design consideration). The management of perched ground water that enters the borrow area excavation is not wastewater; management of this latter runoff is discussed in Section 2.10 of this DCP.

2.8.6 References

FEMP property data and information required to design the surface-water management system should be obtained from the references cited in Section 1.5 of this DCP. References from the general technical literature that may be used to design these systems are given below.

American Concrete Pipe Association, "*Concrete Pipe Design Manual*", American Concrete Pipe Association, Arlington, VA, February, 1970.

Applied Microcomputer Systems, "*HydroCAD™ Stormwater Modeling System*", Version 3.10, Chocorua, NH, 1993.

Chow, V.T., *"Open-Channel Hydraulics"*, McGraw-Hill, Inc., 1959.

Department of Labor, OSHA Construction Standard, 29 CFR 1926.106 "*Working Over or Near Water.*"

Fernald Environmental Management Project, *"Fluor Daniel Fernald Safety Performance Requirements Manual"*, RM-0021.

Ohio Department of Natural Resources - Division of Soil and Water Conservation (ODNR), "*Rainwater and Land Development*", 2nd Edition, 1996.

Parsons, *"2,000-Year Flood and Probable Maximum Flood Sitewide Flood Plain Determination"*, CERCLA/RCRA Unit 2, Project Order 148, Fernald Environmental Management Project, Rev. A, Fairfield, OH, August 1995a.

Richardson, E.V., et al., "*Highways in the River Environment - Hydraulic and Environmental Design Considerations*, U.S. Department of Transportation, Available from Publications Office, Engineering Research Center, Colorado State University, Fort Collins, CO, 1975.

Temple, D.M., Robinson, K.M., Ahring, R.M., and Davis, A.G., *Stability Design of Grass-Lined Open Channels*", U.S. Department of Agriculture, Agriculture Research Service, Agriculture Handbook Number 667, 1987.

U.S. Department of Agriculture-Soil Conservation Service (USDA-SCS), "*Computer Program for Project Formulation, Hydrology*", Technical Release 20 (TR20), U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C., 1975.

U.S. Department of Agriculture-Soil Conservation Service (USDA-SCS), "*National Emergency Handbook, Section 4 - Hydrology*", U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C., 1985.

U.S. Department of Agriculture-Soil Conservation Service (USDA-SCS), "*Urban Hydrology for Small Watersheds*", Technical Release 55 (TR55), U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C., 2nd Edition, 1986a.

U.S. Department of Agriculture-Soil Conservation Service (USDA-SCS), *Engineering Field Manual for Conservation Practices*, U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C., 1986b.

U.S. Department of Agriculture-Soil Conservation Service (USDA-SCS), "*Water Management and Sediment Control for Urbanizing Areas*", U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C., 1987.

U.S. Department of Agriculture-Soil Conservation Service (USDA-SCS), *Ponds - Planning, Design Construction*, Agricultural Handbook Number 590, U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C., November 1988.

U.S. Department of Transportation (USDOT), "*Hydraulic Design of Highway Culverts*", Hydraulic Design Series No. 5, Federal Highway Administration, McLean, VA, September 1985.

U.S. Department of Energy (DOE), "*Technical Approach Document, Revision II*", Uranium Mill Tailings Remedial Action Project, December 1989.

2.9 Support Facilities and Utilities

2.9.1 General Design Criteria

The function of support elements and utilities is to provide support for, and enhance the performance of, the OSDF during construction, filling, closure, and post-closure care. As identified in Section 1.3 of this DCP, the support elements will include survey benchmarks, construction support area, equipment wash facility, materials storage areas, access control features, construction haul roads and leachate transmission system access corridor. Utilities will include electricity, water, and wastewater systems. Design criteria are presented separately in this section for each of these elements.

The support elements must provide adequate and reliable support for the activities that will be performed for the OSDF. Utilities must provide reliable service to the support elements for each type of utility. The support elements and utilities should be developed in a manner that is consistent with the requirements of applicable utility codes at the FEMP and with applicable health and safety requirements for the FEMP.

2.9.2 Specific Criteria

2.9.2.1 Survey Benchmarks

At least three permanent third-order survey benchmarks will be installed on separate sides of the OSDF within easy access of the limits of impacted material placement (ARAR: OAC 3745-27-08(C)(7)). The benchmarks will be constructed in accordance with the following requirements (ARAR: OAC 3745-27-08(C)(7)):

- Survey marks will be referenced horizontally to the 1927 North American Datum, 1983 North American Datum, or State Plane Coordinate System and vertically to the 1929 or 1988 North American Vertical Sea Level Datum as identified on the 7.5 minute series quadrangle sheets published by the United States Geological Survey ((C)(7)(a)).

- Survey marks will be at least as stable as a poured concrete monument 10 in. in diameter installed to a depth of 42 in. below the ground surface. Each survey mark will include a corrosion resistant metallic disk which indicates horizontal and vertical coordinates of the survey mark. Each survey mark will also contain a magnet or ferromagnetic rod to allow identification through magnetic detection method ((C)(7)(b)).

- Survey control standards for the survey marks will be in accordance with the following ((C)(7)(c)):

  - for the first facility survey mark established from the known control point, minimum horizontal distance accuracy will be one foot horizontal to two thousand five hundred feet horizontal;

  - for each facility survey mark established from the first facility survey mark, minimum horizontal accuracy will be one foot horizontal distance to five thousand feet horizontal; and

  - for the first facility survey mark established from the known control point and for each facility survey mark established from the first facility survey mark, minimum vertical accuracy will be one inch to five thousand feet horizontal.

2.9.2.2 Utilities

Design criteria for utilities for the OSDF are given below.

- The utility types and demand should be evaluated based on the requirements for both temporary construction facilities during each stage of construction, filling, and closure of the OSDF and requirements for the post-closure care period (design consideration).

- The design of the utilities must be performed using regulations and guidance from USOHSA, local and state governments, OEPA, Cincinnati Gas & Electric, other public utilities, ASTM, ASCE, ANSI, ACI, NEC, and other groups which promote safety and design standards for utilities supply. The design of utilities should also comply with FEMP site facility standards (functional requirement).

- Good safety practice should be used in designing the utilities layout, installation requirements, and operations and maintenance. Adequate space will be provided for safe and efficient access for inspection and maintenance. Valves and switches should be directly lockable to facilitate lockout/tagout requirements. The use of chains or other extra equipment is not an acceptable method to "lockout" the valve or switch. Valves, piping, and switches will be labeled as to service and flow direction. Valves and other control devices will be located and installed in accordance with good ergonomic practice for safe and effective operation (design consideration).

- The utility services design should be from the point of service to the battery limit. Design of the utilities from the battery limit to the utility sources will be performed as part of a separate design package being prepared under the integrated FEMP remediation (design consideration).

- The routing of utilities should be based on consideration of avoiding areas that are to be demolished or developed, on-site soil remediation areas, and borrow areas in which excavation is planned (design consideration).

- The utilities should be installed at a depth sufficient to prevent damage due to freeze-thaw effects (design consideration).

- The utility lines should be designed to accommodate vehicle and/or railroad loadings at locations where the utilities will cross beneath haul roads, access roads, or railroads (design consideration).

- A water supply should be provided for dust suppression and moisture control during construction of the OSDF and placement of impacted material therein. Water supply points should be provided convenient to equipment used in construction of the OSDF (design consideration).

2.9.2.3 Construction Administration Area

Design criteria for the construction administration area are given below.

- The activities related to construction administration should be conducted in temporary facilities or trailers (design consideration).

- Trailers should be located within a fenced-in area and on a paved or gravel surface within the battery limit (design consideration).

- Temporary facilities or trailers should be designed having an adequate amount of space for the activities that will occur in the trailer (design consideration).

- Temporary facilities or trailers should be provided with adequate parking and all-weather ingress and egress (design consideration).

- The temporary facilities or trailers, including construction standards, tiedowns, utility provisions, and access provisions, must satisfy local codes and regulations (design consideration).

- If trailers are used, the installation of the trailers will conform to the requirements of NFPA 70, *"National Electric Code"* (DOE-STD-1088-95) (design consideration).

2.9.2.4 Equipment Wash Facility

An equipment wash facility will be used for washing equipment exposed to impacted material within the battery limit. A wash pad should be provided in order for equipment to pass from the active impacted material work area in an OSDF cell or other area designated for clean-up to the area of OSDF construction or other areas designated and confirmed to meet FEMP clean-up criteria (functional requirement). The equipment wash facility must be designed to (functional requirements):

- be capable of washing the undercarriage and exterior of a vehicle to remove particulate matter, using high pressure spray from portable hand-held sprayers; the wash stations may be temporary and transportable; side panels should be used to control fugitive emissions from the wash stations;

- be large enough to contain runoff and spray water from the washing of construction and other equipment;

- contain wastewater and solids that are generated by the washing process;

- have a containment system beneath the equipment washing surfacing; if the washing facility is a stationary, constructed facility, it should include, at a minimum, an HDPE geomembrane liner overlain by a granular drainage layer; the containment system should convey any flow to a sump accessible for pump-out using a portable submersible pump; and

- have a sump, pump, and plumbing system to evacuate wastewater from the facility and route it to the leachate transmission system, or by gravity to the FEMP former production area storm drainage control system, or other acceptable wastewater collection/conveyance point; the sump pump, plumbing and routing system should be designed for the 10-year, 24-hour storm event.

In addition, large off-road earth moving equipment may be washed inside an active cell with a portable high-pressure spray. Washing activities in an active cell will be confined to designated areas so as not to interfere with impacted material placement operations. The runoff from washing activities will be allowed to percolate into the cell leachate collection system (design consideration).

2.9.2.5 Material Storage Areas

Material storage areas will be used by the OSDF construction contractor to store materials that will subsequently be used in constructing, filling, and closing the OSDF.

In general, material storage areas should include a construction materials (e.g., geomembrane, pipe, etc.) storage area and a non-impacted soil stockpile area. The material storage areas should be (design considerations):

- located within the battery limit;
- large enough to contain the materials that will be used during construction of each phase of the OSDF;
- located in an area that is convenient to the OSDF construction area;
- located within an area where runoff is routed to a sediment basin; and
- designed with runon diversion controls.

2.9.2.6 Access Control

Access control features should provide control over ingress to, and egress from, the OSDF (functional requirement). One of the primary features of the access control system is installation of a security fence around the active construction area, with storage, support, and administration areas also enclosed by security fencing. The fencing is intended to prevent unauthorized access to the OSDF. The access control features must be designed as described below (design considerations).

- Security fencing should be of chain link construction and satisfy Ohio Department of Transportation (ODOT) standard specifications.
- Signs warning unauthorized individuals to keep out should be placed on the fence at 50 ft intervals.
- Authorized personnel and vehicle access should be through a lockable access control gate.
- Access gate(s) should be placed at location(s) that are convenient for controlling access to the facility, while not unnecessarily limiting access.
- The security fence should be designed so that it does not inhibit flow at locations where it crosses surface-water drainage features.

- Access control facilities should be designed to allow monitoring of equipment used to transport both impacted materials and construction materials.

- Access control should consider the need for, and permit rapid response and ready access to all locations in the OSDF for emergency vehicles, personnel, and equipment in the event of an incident (design consideration).

2.9.2.7 Construction Haul Roads and EPLTS Access Corridor

Construction haul roads should be provided for the equipment that transports soils from the borrow area to the OSDF cell construction site (functional requirement). An EPLTS access corridor should be provided for the equipment that maintains the EPLTS during OSDF filling, closure, and post-closure periods (functional requirement). The following criteria should be used in designing construction haul roads and the EPLTS access corridor within the battery limit.

- Unpaved roads should be designed using methods appropriate to that type of road (design consideration). Culvert crossings beneath roads should be designed for AASHTO H-20 live loads (functional requirement) plus applicable dead loads.

- The maximum design speed for haul roads and the access corridor should be 20 miles per hour (mph) (design consideration).

- The design life for construction haul roads should be based on a maintenance interval of one to two weeks during the construction season (design consideration). The design life for the EPLTS access corridor should be based on maintenance intervals of 12 months (design consideration).

- The minimum acceptable section for the construction haul roads and the EPLTS access corridor is, from top to bottom (design consideration):

    - 12-in. thick layer of free-draining crushed gravel;

    - geotextile separator; and

    - prepared subgrade.

- Minimum construction haul road widths should be as follows (design consideration):
  - one-way, single-lane construction haul roads should be 16 ft wide with shoulders of up to 5 ft on both sides of the road to accommodate vehicles having large widths; and
  - two-way, double-lane construction haul roads should be 32 ft wide with shoulders of up to 5 ft on both sides of the road.
- Minimum EPLTS access corridor width should be 12 ft, with minimum 3 ft shoulder on downhill side of the access corridor (design consideration).
- Construction haul roads should be designed with a 3 percent cross slope or crown. These roads should also have edge ditches for runoff and runon control (design consideration).
- Wherever possible construction haul road grades should be 3 percent, or less. Where required to obtain cell access, road grades as steep as 10 percent may be allowed for short distances (design consideration).
- The EPLTS access corridor should be designed with a minimum 3 percent cross slope or crown and a maximum grade matching the grade of the EPLTS (design consideration).
- Road turning radii should be at least 50 ft at the centerline of the road (design consideration).
- Roads should be designed to include signage in accordance with ODOT standards (design consideration).

Cut and fill slopes for construction haul roads should be designed to have a maximum side slope of 3H:1V. Where construction activities or other spatial constraints limit right of way, cut and fill having a maximum slope of 2H:1V may be used if shown to be stable (design consideration). Drainage ditches should be used to convey runoff from the haul roads (design consideration).

2.9.2.8 Calculations

The following calculations should be prepared in development of the design of the support facilities and utilities:

- electrical power demand: estimate the electrical power requirements for the construction administration area, materials storage areas, equipment wash facility, and permanent lift station;

- potable water demand: estimate the potable water requirements for the construction administration area (to include fire protection), for clay liner, cap, and general earthwork construction, and for dust control;

- sanitary wastewater discharge: estimate the sanitary sewer discharge for the construction administration area;

- wash facility water demand: estimate the water demand for the equipment wash facility;

- wash facility pump design: calculate the required pump capacity;

- construction administration area surfacing: calculate the required asphalt pavement and aggregate base course thicknesses;

- construction haul road design: calculate the required aggregate base and subbase coarse thicknesses; and

- EPLTS access corridor design: calculate the required aggregate base and subbase coarse thicknesses.

2.9.3 References

FEMP property data and information required to design the support facilities and utilities should be obtained from the references cited in Section 1.5 of this DCP. References from the general technical literature that may be used to design these activities are given below.

American Association of State Highway and Transportation Officials (AASHTO), "*AASHTO Guide for Design of Pavement Structures*," Washington, D.C., 1992.

Portland Cement Association (PCA), "*Thickness Design for Concrete Highway and Street Pavement*", 1984.

State of Ohio, Department of Transportation (ODOT), "*Location and Design Manual, Volume I, Roadway Design*", Revision, October 1992, Columbus, OH, 1992.

State of Ohio, Department of Transportation (ODOT), "*Construction Materials Specifications*," Columbus, OH, January 1993.

Yang, H.H., "*Pavement Analysis and Design*", Prentice-Hall, Inc., New York, NY, 1993.

Yoder, E. and Witczack, M., "*Principles of Pavement Design*", John Wiley and Sons, Inc., New York, NY, 1975.

2.10 Borrow Area

2.10.1 General Design Criteria

The function of the borrow area is to provide soil for construction of the liner and final cover systems, and for other earthwork, related to construction, filling, and closure of the OSDF. This consists of soil borrow for construction of the compacted clay liner and cap, vegetative soil layer, compacted fill, and other earthwork associated with the project. The topsoil layer in the borrow area will be removed and stockpiled for later use unless it is determined to be impacted material, in which case it should be disposed of in the OSDF in accordance with the Impacted Material Placement Plan (IMP Plan). The borrow area for OSDF construction is located in the "East Field" area of the FEMP property. This borrow area will be developed over a period of time from 7 to 25 years (depending on the actual schedule for OSDF construction, filling, and closure), with a 10-year design life used for planning purposes. After the borrow area is restored, it should function with minimal maintenance.

The borrow area should be developed in a manner that results in efficient utilization of the available soils, results in efficient utilization of the natural topography of the borrow area to effectively control runon and runoff, provides soils with the engineering properties required for the OSDF earthwork components being constructed, and minimizes the costs associated with the development and restoration of the area (design considerations). In addition to these requirements, the design of the borrow area should consider the requirements described below (design considerations).

- The borrow area should be laid out in a manner that provides easy ingress and egress.
- The area should be developed in a manner that requires minimal additional earthwork after borrow activities are complete to achieve the required restoration grades.
- The borrow area should be developed incrementally as soil is needed for construction of the OSDF.
- The size of disturbed borrow area should be minimized to the extent possible.
- Interim restoration should be performed progressively as excavation in each borrow area subarea is completed.
- Erosion and sediment controls should be implemented in the borrow area prior to excavation, during borrow activities, and in conjunction with restoration activities.

2.10.2 Specific Criteria

2.10.2.1 Location of Borrow Area

A. Design Criteria

- The borrow area should be located in an area having material quantities and types sufficient for OSDF construction, filling, and closure (design consideration).
- The borrow area should be located within the FEMP property and should not encroach on the transmission line, oil pipeline, or other easements (design consideration).

- The borrow area should not extend vertically into the gray till except as noted in the approved *Borrow Area Strategy Report* (Fluor Fernald, Inc. 2000). The reasons for this are: (i) the efficiency of the borrow area operation will be improved by limiting the depth of excavation; and (ii) by limiting the depth of excavation, the restored borrow grades will be flatter and restoration of the area will be more cost effective. The borrow area should be constructed with sufficient final slope to minimize erosion and support final restoration (design considerations).

- Within the above constraints, the borrow area should be as deep as possible to minimize the size of the area (design consideration).

B. Calculations

No formal calculation is required for the location of the borrow area. A review of past geotechnical investigations and the results of ongoing laboratory testing of borrow area soil samples collected in November 1995 should be conducted to assess the engineering properties of the material and to predict the suitability of the materials for use as compacted clay liner and cap materials, as well as other earthwork components of the OSDF, as listed in Section 2.10.1.

2.10.2.2 Layout of Borrow Area

A. Design Criteria

- The borrow area should be laid out to facilitate surface-water management throughout the life of the borrow area (design consideration).

- The borrow area should be graded to promote surface-water runoff and prevent ponding of surface water (design consideration).

- The borrow area should be laid out to avoid interferences with roads, utility corridors, easements, etc. (design consideration).

- A soil contingency volume (equal to at least 15 percent of the required soil bank/unbulked volume based on the design estimate) should be provided in the borrow area for possible use in (design consideration):

- construction of an OSDF contingency cell if disposal volumes are larger than anticipated;

- backfilling to subgrade elevations beneath the footprint of the OSDF in the event that additional excavation of impacted material is necessary;

- constructing portions of the contouring layer of the cover system and the non-granular portion of the protective layer of the liner system with "non-impacted" soil; and

- providing material for "seasonal" closure between construction seasons in the event that suitable impacted soil is not available for this purpose.

- Intermediate borrow area slopes should be cut at a safe angle of repose for the material (design consideration).

- Permanent restored slopes within the borrow area should be no steeper than 5H:1V (design consideration).

- As may be required, design will comply with OSHA requirements, 29 CFR 1926 Subpart P-Excavations.

B. Calculations

A review of previous geotechnical field and laboratory test data, including brown till in-situ densities and moisture contents, standard Proctor compaction test results, and permeability test results should be made. The results of previous laboratory testing of borrow area soil should also be reviewed. The calculations described below should be undertaken in support of the design of the borrow area.

- The bank/unbulked volume of borrow soil required to build the earthwork components of the OSDF described in 2.10.1 should be calculated. The calculation should be conducted using the required compacted earthwork volume of on-site borrow material. This required compacted earthwork volume should be corrected to account for shrinkage/bulking of the borrow soil, the possible need for contingency volume, and the removal of the topsoil layer for stockpiling and later use as the topsoil layer in the OSDF final cover system.

- The bank/unbulked volume of available borrow soil, as calculated using computed-aided design (CAD) techniques, should be verified by hand calculation.

- The in-situ moisture content of the soil at the borrow area should be compared to the anticipated compaction moisture contents for the various earthwork components of the OSDF liner and final cover systems to assess the construction water demand and/or amount of soil drying required to moisture condition the borrow soils.

2.10.2.3 Development of Borrow Area

A. Design Criteria

- The borrow area should be developed in a manner that produces consistent materials for construction of the OSDF and effectively utilizes the existing topography to control surface-water runoff and runon (design consideration).

- Requirements for processing of the borrow area soils should be identified during design. If possible, such processing should be performed in the borrow area or any temporary stockpile area. Such processing could include moisture conditioning, blending, screening, or admixture modification (design consideration).

- Prior to the start of construction in the borrow area, the following activities should be performed (design considerations):

  - establishment of temporary surface-water management and erosion and sediment controls for the borrow area, including sediment basins;

  - establishment of access controls for the borrow area (consistent with the requirements of Section 2.9.2.6 of the DCP); and

  - establishment of soil processing facilities (if any are needed).

- Prior to the start of borrow area development, topsoil in the area should be removed and stockpiled for later use for closure of the OSDF unless it is determined to be impacted material, in which case it should be disposed in the OSDF in accordance with the IMP Plan (design consideration).

B. Calculations

No formal calculations are required for the development of the borrow area.

2.10.2.4 Surface-Water Management for Borrow Area

A. Design Criteria

- Temporary and permanent surface-water control structures for the borrow area with the exception of sediment basins, should be designed for the 25-year, 24-hour storm event (design consideration). Depending on the size of the contributory area, sediment basins should be designed for either the 10-year, 24-hour storm event, or the 25-year, 24-hour storm event [ODNR, 1996]. This criterion is discussed further later in this section of the DCP.

- Surface-water runoff from the FEMP watersheds to the receiving water course (e.g., Paddys Run) should be discharged at a rate no greater than the predevelopment runoff discharge rate [ODNR, 1996] (design consideration).

- Surface-water runoff should be managed so that, after restoration of the borrow area, the effects of erosion of the borrow area ground surface are minimal. Long-term erosion of the ground surface in the borrow area must not impact the OSDF (design considerations).

- Temporary runon control structures should be implemented to minimize runon from entering work areas. Such runon should be diverted around work areas using diversion dikes or channels as appropriate (design consideration).

- Temporary channels for surface-water runoff should be designed to meet the criteria presented in Section 2.8.3 of the DCP (design consideration).

- Permanent channels should be designed to meet the criteria presented in Section 2.8.4 of the DCP (design consideration).

- Culverts should be designed to meet the criteria presented in Section 2.8.4 of the DCP (design consideration).

- Riprap should be designed to meet the criteria presented in Section 2.8.4 of the DCP (design consideration).

- Sediment basins should meet the following criteria [ODNR, 1996] (design considerations).

    - The minimum capacity of the sediment basin to the elevation of the crest of the pipe spillway should be 1,800 cubic ft for each acre within the drainage area that will be disturbed by construction during the design life of the sediment basin.

    - The capacity of the pipe spillway should be sufficient to pass the runoff from the 2-year, 24-hour storm event. For the FEMP property, this event has a rainfall intensity of 2.5 in. [Parsons, 1995a].

    - The combination of the principal and emergency spillways should be capable of safely discharging the flow from the 10-year, 24-hour storm event if the drainage area to the sediment basin is less than or equal to 20 acres, or the 25-year, 24-hour storm event if the drainage area to the sediment basin is greater than 20 acres.

    - Consideration should be given to using the permanent Fernald facility main entrance road as a containment dike for the surface-water runoff in lieu of an emergency spillway.

    - If an emergency spillway is implemented, a minimum freeboard of 1 ft measured from the peak water elevation in the emergency spillway to the top of the embankment, should be provided.

- Temporary erosion control measures should include those items described in Section 2.8.3 in the DCP (design consideration).

It is noted that surface-water routing and surface-water management system design for watercourses and structures beyond the battery limit will be addressed in other design packages being prepared as part of the integrated FEMP remediation.

B. Calculations

Calculations should be performed to route the design storm through the borrow area for existing conditions and for construction conditions (i.e., during borrow activities), and to size sediment basins. The calculations should be performed as described below.

- The amount of surface-water runon and runoff should be calculated for each contributory drainage area.
- The size of the sediment basin, including outlet structures, should be calculated for each contributory drainage area.

The above calculations should be performed using the design storm events previously identified. Runon/runoff routing and sediment basin sizing should be evaluated using the procedures described in USDA-SCS Technical Release 20 and/or 55 [USDA-SCS, 1975, 1986a]; an acceptable tool for performing these calculations is the computer program "*HydroCAD™ Stormwater Modeling System*" [Applied Microcomputer Systems, 1993]. The above evaluations should be based on the information and guidance contained in USDA-SCS manuals [1985, 1986b, 1987, 1988].

In the event that a channel bottom grade is less than 0.5 percent, an analysis should be performed to establish that the channel does not clog or build up sediment that will cause loss of flow capacity in the design storm event.

2.10.2.5 Restoration

A. Design Criteria

The borrow area should be restored in accordance with the approved *Borrow Area Strategy Report* (Fluor Fernald, Inc., 2000) and *Borrow Area Management and Restoration Plan* (GeoSyntec, 2000) to a condition that requires minimal maintenance (functional requirement). The borrow area should be restored to a condition that is consistent with the geomorphological character of the area surrounding the FEMP (design consideration). The following criteria should be followed in preparing the restoration plan for the borrow area.

- Final grades should be selected that minimize long-term erosion in the area. The final grades should not result in erosion that is greater than the calculated erosion rate for stabilized slopes in the vicinity of the FEMP that have similar grades and similar soil types (design consideration).

- Surface-water runoff from the restored borrow area should be routed as indicated in Section 2.10.2.4 (design consideration).

- The restored borrow area should be revegetated with plant species that minimize erosion, that can be successfully established given the design final grades and soil types, and that are self-propagating in the expected conditions of the restored borrow area (design consideration).

- The design of the restoration plan should provide for progressive restoration of the borrow area, with commencement of restoration in an area as soon as borrow activities have been completed. To the extent possible, activities should not be performed in portions of the borrow area that have been restored (design consideration).

B. Calculations

No formal calculations are required for restoration of the borrow area. Procedures and materials for establishing permanent vegetation in the borrow area should be consistent with those procedures and materials selected for the OSDF final cover system (see Section 2.6 of this DCP).

2.10.3 References

FEMP property data and information required to design the borrow area should be obtained from the references cited in Section 1.5 of this DCP. References from the general technical literature that may be used to design the borrow area are given in Section 2.8.6 of the DCP. Additional references are as follows:

Fluor Fernald, Inc. "*Borrow Area Strategy Report*", Revision O, Fernald, OH, April 2000.

GeoSyntec Consultants, Inc., "*Borrow Area Management and Restoration Plan*", Revision 1C, Atlanta, GA, April 2000.

2.11 Impacted Material Management

2.11.1 General Design Criteria

This section of the DCP addresses impacted material management activities within the OSDF battery limit. Other activities, primarily associated with remediation of the operable units, and use of an OMTA or other temporary staging areas outside of the battery limit, are addressed in other design packages being prepared as part of the integrated FEMP remediation.

Impacted material management activities must be conducted in a manner that is protective of the OSDF liner system, leachate management system, and final cover system, that prevents the uncontrolled release of impacted material to the environment, and that is safe and cost effective. In this section of the DCP, the criteria that should be followed for the design of impacted material management facilities associated with the OSDF are described. Impacted material should be placed in accordance with the "*Impacted Material Placement Plan*," which will be prepared as described in Section 3.2.6.2. Impacted material management activities will include: (i) transporting impacted materials from areas within the battery limit where the materials are excavated to either the OMTA or stockpiling areas and/or the OSDF; (ii) transporting impacted material from operable units to either temporary staging areas and/or the OSDF; (iii) placing the material within the OSDF; and (iv) managing the generation of fugitive emissions and wastewaters during impacted material placement operations.

Facilities for impacted material management should (functional requirements):

- be located in areas that can easily and efficiently accommodate receipt of impacted material from the various FEMP operable units;
- be separated from non-impacted areas;
- limit the uncontrolled discharge of fugitive emissions to acceptable levels;
- limit the generation of wastewaters to acceptable levels;
- comply with project health, safety, and radiological requirements;

- be removed at the completion of impacted material management activities, with the disposal of affected materials in the OSDF; and
- be designed to minimize the generation of new impacted material.

2.11.2 Specific Design Criteria

2.11.2.1 Impacted-Material Haul Roads

A. Design Criteria

Temporary haul roads should be provided for the equipment that transports impacted material (functional requirement). The following criteria should be used in designing impacted material haul roads within the battery limit.

- Unpaved roads should be designed using methods appropriate to that type of road (design consideration). Culvert crossings beneath roads should be designed for AASHTO H-20 live loads plus applicable dead loads (functional requirement).
- The maximum design speed for paved haul roads should be 20 miles per hour (mph) (design consideration).
- The maximum design speed for unpaved haul roads should be 10 miles per hour (mph) (design consideration).
- The design life for impacted material haul roads should be based on a maintenance interval of one to two weeks during the construction season (design consideration).
- The minimum acceptable section for impacted material haul roads is (design consideration):
    - 12-in thick layer of free-draining crushed gravel;
    - geotextile separator; and
    - prepared subgrade.

- Minimum impacted material road widths should be as follows (design consideration):

  - one-way, single-lane impacted material haul roads should be 16 ft wide with shoulders of up to 5 ft on both sides of road to accommodate vehicles having large widths; and

  - two-way, double-lane impacted material haul roads should be 32 ft wide with shoulders of up to 5 ft on both sides of road.

- Impacted material haul roads should be designed with a 3 percent cross slope or crown. These roads should also have edge ditches and berms for runoff and runon control (design consideration). The berms shall be designed to incorporate safety for the haul trucks.

- Wherever possible, impacted material haul road grades should be 3 percent, or less. Where required to obtain cell access, road grades as steep as 10 percent may be allowed for short distances (design consideration).

- Road turning radii should be at least 50 ft at the centerline of the road (design consideration).

Cut and fill slopes for impacted material haul roads should be designed to have a maximum side slope of 3H:1V. Where construction activities or other spatial constraints limit right of way, cut and fill having a maximum slope of 2H:1V may be used if shown to be stable (design consideration). Drainage ditches should be used to convey impacted runoff from the haul roads to impacted-runoff sumps (design consideration). Water collected in impacted-material haul road sumps should be treated as wastewater and managed as described in Section 2.8.5 of this DCP (design consideration).

B. Calculations

Impacted material haul roads should be designed for the anticipated type and volume of traffic that will pass over the road. Road layouts should be calculated using standard CADD-based procedures for horizontal and vertical control. If unpaved, the roads should be designed using standard techniques for design of unpaved roads (for example, as described by Giroud and Noiray [1981] or using the AASHTO method

[AASHTO, 1993]. If paved, roads will be designed using the most current AASHTO procedures. Roads should be designed to allow use of locally available aggregates and construction materials, such as those materials identified in the ODOT standard specifications.

2.11.2.2 Impacted Material Staging Areas

A. Design Criteria

The construction of impacted-material staging areas may be required during OSDF filling. To the extent feasible, impacted materials, other than impacted soils, should be staged on existing building slabs within the FEMP former production area (design consideration). If an impacted-material staging area is required within the battery limit for materials other than impacted soil, it should meet the requirements given below:

- Any impacted-material staging area within the battery limit should incorporate a gravel or concrete working pad (design consideration). Any concrete working pad should be designed in accordance with ACI 318-93 [ACI, 1993] (design consideration). The working pad, whether gravel or concrete, should include a containment system that includes as a minimum, from top to bottom (functional requirement):
    - working surface of suitable thickness and strength, capable of supporting both on-road and off-road impacted material haul vehicles in a manner that does not damage the underlying containment system;
    - 12-in. thick layer of free-draining crushed gravel;
    - geotextile cushion layer;
    - 40-mil thick HDPE geomembrane; and
    - prepared subgrade.

Any impacted-material staging area within the battery limit for materials other than impacted soil should also:

- contain and control impacted runoff from the staging area and manage that runoff as wastewater using the criteria described in Section 2.8 of this DCP (design consideration);
- prevent surface-water runon to the area through use of a perimeter curb or berm (design consideration);
- enable access by equipment for placement and removal of material (design consideration); and
- have provisions for fugitive emissions control using either geosynthetics, water spray, crusting agents, surfactants, or other appropriate methods (design consideration).

To the extent the stockpiling of impacted soil is necessary stockpiling activities should be contained within the FEMP former production area (design consideration). If necessary to temporarily stockpile impacted soil within the battery limit, the temporary stockpile should (design considerations):

- contain and control impacted runoff from the staging area and manage that runoff as wastewater using the criteria described in Section 2.8 of this DCP;
- prevent surface-water runon to the area through use of a perimeter curb or berm;
- enable access by equipment for placement and removal of material; and
- have provisions for fugitive emissions control using either geosynthetics, water spray, crusting agents, surfactants, or other appropriate methods.

B. Calculations

An evaluation should be performed of the required size and storage capacity of any impacted-material staging area required within the battery limit. The evaluation should verify that the maximum anticipated quantity of material requiring staging at any point in time can be accommodated. Standard engineering methods for calculation of volumes should be used. Calculations should also be performed to design any concrete working pad to resist the applied traffic loads.

2.11.2.3 Impacted Material Excavation, Removal, and Handling

- As Low As Reasonably Achievable (ALARA) goals should apply to all impacted-material excavation, removal, handling, and placement activities (DOE Order 5400.5, Chapter I(4) and II(2)).

- Procedures should be employed that minimize the need for the use of respirators by on-site workers (design consideration).

- Impacted soil encountered in the OSDF area should be managed as follows (design considerations).

  - The top layers of soil in areas indicated on the drawings as impacted should be removed. The depth of removal should be addressed as part of other design packages prepared as part of the integrated FEMP remediation. Such soils should either be stockpiled for later placement in the OSDF or, preferably, transported and placed directly in the OSDF, depending on the availability of a suitable location within the OSDF.

  - Temporary stockpiles for impacted soils within the battery limit should be constructed as described in Section 2.11.2.2 of this DCP.

  - Runon to excavation areas should be prevented to the extent possible, as described in Section 2.8 of this DCP. The size of the active excavation area should be limited to minimize the potential for surface-water runoff from the area.

  - Overexcavation of impacted material should be minimized.

  - The soil beneath the removed layer should be sampled and tested as addressed in other plans prepared as part of the integrated FEMP remediation. Additional excavation may be needed based on the results of confirmation sampling.

  - Excavated areas that will not immediately undergo further development should be promptly revegetated to minimize the potential for erosion.

2.11.2.4 Impacted Material Transport

A. Design Criteria

The following criteria and requirements should be incorporated into the *Impacted Material Placement Plan.*

- The OSDF construction contractor should control the release of fugitive emissions (including dust, radiological, chemical, and asbestos materials) so that air quality standards are not violated on the site and so that releases are controlled to acceptable levels at the fence line (design consideration).

- Material transport procedures should be designed to cause minimal disturbance to the site and work area (design consideration).

- Material transport procedures should be designed in coordination with impacted material removal and impacted material placement activities (design consideration).

- Material transport equipment requirements should address the need to transport a variety of materials so that the number of pieces of equipment required to implement the design is minimized (design considerations).

- Impacted material transport equipment requirements should address the control of airborne particulate emissions (design consideration).

- Acceptable emission control methods include (design consideration): •transport in closed containers with metal or tarp lids;

  - keeping impacted material moist; and

  - spraying earthen material with a crusting agent.

- Crusting agents should be evaluated for compatibility with OSDF liner system components and only agents that contain constituents known to be compatible should be used (design consideration).

2.11.2.5 Impacted Material Placement

A. Design Criteria

Only material satisfying the OSDF WAC will be placed in the OSDF (functional requirement). Impacted material placement activities should result in the disposal of impacted material in a manner that prevents unacceptable worker exposure to health and safety hazards, and in a manner that achieves the long-term performance goals of the OSDF (design considerations).

Impacted material placement procedures should take into account (design considerations):

- the rate and time at which impacted material will be available for placement in the cell;
- the types of impacted material available for disposal (i.e., soil, flyash, lime sludge, solid waste, and building demolition debris);
- the potential for bulking/shrinkage of impacted material during placement;
- the availability of temporary stockpile capacity;
- the extent to which the disposal cell is constructed and available to receive impacted material; and
- the need for suspended or reduced impacted material placement activities during winter and preparedness for seasonal (winter) shutdown.

In addition to the foregoing requirements, impacted material placement activities should be designed to achieve the following (design considerations).

- Impacted material should be placed in the OSDF in such a manner that the OSDF will achieve the design life goal of 1,000 years to the extent reasonable, and in any case at least 200 years.
- Impacted material should be placed in a manner that is protective of the liner system and final cover system.

- Impacted material should be placed so that it will remain stable under both static and earthquake loading conditions.

- Impacted material should be placed to minimize differential settlement to the extent reasonably achievable.

- A minimum of 3 ft of select impacted material should be placed directly over the protective layer component of the liner system, and beneath the contouring layer component of the final cover system, to provide protection of these systems from damage by impacted materials (see Figure 1-1 of this DCP). The thickness of select impacted material over the protective layer may be decreased to 2 ft if the first lift of material to be placed over the select impacted material consists of Category 1 material.

- To limit particulate emissions, generation of wastewaters, and erosion of impacted material, the sequence of placement should be designed to minimize the area of exposed impacted material.

- Materials should be placed in a manner that results in a disposal pile with relatively homogenous large-scale mechanical properties (i.e., compressibility and shear strength), to the extent possible. Homogeneity should be achieved by distributing impacted materials throughout the OSDF to avoid large pockets or distinct concentrations of any one type of impacted material in a particular area. The objective of achieving a homogenous disposal pile is to minimize the potential for differential settlement.

- Municipal solid waste material requiring disposal should be spread out in relatively thin lifts and covered with at least 12 in. of cover soil. The purpose of this procedure is to minimize the potential for anaerobic decomposition of the waste (and, thus, the generation of landfill gas) and also the potential for differential settlement of the disposal pile. Similarly, green waste from excavation activities requiring OSDF disposal should be spread out in thin lifts and completely covered with soil. Consideration should be given to chipping any tree limbs and branches requiring OSDF disposal to reduce the size of the green waste particles prior to disposal.

- At the end of each work day, the impacted material surface should be graded and maintained to control precipitation runoff and impacted material erosion.

In addition to the foregoing, placement of impacted material in an OSDF cell will be performed such that the cell can always store runoff from active and open portions of the cell resulting from the 25-year, 24-hour storm event (ARAR: OAC 3745-027-08(C)(6)).

B. Calculations

Calculations should be conducted to estimate potential total and differential settlements of the disposal pile. These calculations should be conducted as described in Section 2.3.2.4 of this DCP. Calculations should also be performed to estimate the required cell storage to contain impacted materials from the 25-year, 24-hour storm event. These calculations should be performed as described in Section 2.5.1 of this DCP.

2.11.2.6 Seasonal (Winter) Shutdown

Temporary shutdown of impacted material placement activities will be required during periods of freezing conditions and at locations where impacted material will not be placed for at least 45 days. In these cases, a "seasonal" cover consisting of soil material should be provided to cover exposed surfaces of Category 2 through Category 5 material; and be stabilized by suitable surface protection, crusting agents, or geosynthetic erosion control matting. Seasonal cover should (design considerations):

- have the least volume technically practical in order to limit loss of cell volume ;
- be cost effective to place;
- be of sufficient thickness to protect underlying geosynthetics from frost effects;
- control surface-water runoff and route runoff to a location where it can be properly managed;
- limit infiltration through previously placed impacted materials and minimize impacted material erosion;
- limit fugitive emissions to not more than acceptable levels; and
- remain stable and durable for the anticipated period of seasonal shut-down.

Potential "seasonal" cover materials that should be evaluated as part of the OSDF design include on-site impacted materials with suitable surface protection (e.g., commercially-available surfactant products or crusting agents). Runoff from seasonally-covered impacted material slopes should be managed as leachate (design consideration).

2.113 Radon Emission and Gas Generation

A. Design Criteria

The following radon and gas generation design criteria apply to the OSDF and should be addressed.

- Release of radon-222 to the atmosphere will not: (i) exceed an average release rate of 20 picoCuries per square meter per second (pCi/m^2/s); or (ii) increase the average annual concentration of radon-222 at or above any location outside the OSDF by more than 0.5 picoCuries per liter (pCi/l) (ARAR: 40 CFR §192.02(b)).

- The amount of labile (i.e., easily assimilatable) organic carbon placed in the OSDF should not be so great as to cause a sufficient volume of methane generation to: (i) create a health and safety concern to the OSDF construction contractor; or (ii) cause cracking or uplift of the OSDF final cover system (design consideration). If health and safety concerns, or final cover system design issues, are identified, mitigative measures should be specified. These measures potentially include: (i) reducing the volume of labile organic carbon (e.g., grubbing wastes, MSW, etc.) disposed in the OSDF; (ii) providing engineering controls (e.g., active ventilation and methane detectors) in manholes and lift stations with pipes open to the OSDF; and (iii) incorporating a gas venting layer into the OSDF final cover system.

- The *Impacted Material Placement Plan* should require impacted material placement procedures that result in the most uniform dispersion of organic material that is practical in order to minimize the concentration of labile organic carbon available to methanogenic bacteria at any one location (design consideration). Methanogenesis rates are directly proportional to the local concentration of labile organic carbon [Amaral and Knowles, 1994].

- To the extent allowed by other design considerations, the final cover system should be designed to provide a favorable environment for methanotrophic bacteria (design consideration). The ability of certain methanotrophic species of bacteria, which would typically be present in landfill cover soils, to consume methane produced in underlying soil or waste layers has been demonstrated [Knightly et al., 1995].

B. Calculations

The radon emission rate should be estimated using the computer code RAECOM [NRC, 1984]. Initially, conservative estimated input parameters, rather than measured site-specific input parameters, should be used. The estimated radon emission rate obtained using this approach should be compared to the ARAR for radon release. If the estimated rate is not more than 25 percent of the ARAR release rate, the calculation is complete. If the estimated rate is more than 25 percent of the ARAR release rate, a more detailed calculation, using site-specific data to establish input parameters, should be undertaken.

The potential for methane generation in the OSDF should be evaluated as follows.

- The maximum total methane generation potential of the OSDF should be estimated using a stoichiometric conversion of the labile organic carbon content of the material in the OSDF to methane; one such conversion procedure is that in Thorneloe et al. [1993].

- A range of potential methane generation rates within the OSDF should be estimated based on a qualitative evaluation of the likely impacts of OSDF environmental conditions (e.g., temperature, moisture content availability, etc.) on methanogenesis activity; descriptions of the impacts of environmental conditions on methanogenesis activity can be found in Amaral and Knowles [1995], Atlas [1984], and Sims et al. [1989]. The conservative assumption that emission rate equals generation rate should be used initially.

- The potential health and safety impacts of the calculated emission rate should be evaluated and appropriate mitigation measures should be instituted if health and safety impacts are indicated by the evaluation.

- The potential effects of the calculated emission rates on the OSDF final cover system should be evaluated and appropriate mitigation measures should be instituted if indicated by the evaluation.

2.11.4 References

FEMP property data and information required to design the impacted material management activities should be obtained from the references cited in Section 1.5 of this DCP. References from the general technical literature that may be used to design these activities are given below.

Amaral, J.A. and Knowles, R., "Methane Metabolism in a Temperate Swamp", *Applied and Environmental Microbiology*, Volume 60, 1995, pp. 3945-3951.

American Association of State Highway and Transportation Officials (AASHTO), "*AASHTO Guide for Design of Pavement Structures*," Washington, D.C., 1992.

American Concrete Institute (ACI), "*Building Code Requirements for Concrete (ACI 318-93)*", Detroit, MI, 1993.

Atlas, R.M., *Microbiology: Fundamentals and Applications.* Macmillan Publishing Company, New York, 1984.

Giroud, J.P., and Noiray, L., "Design of Geotextile Reinforced Unpaved Roads," *J. Geotechnical Engineering Division,* ASCE, Vol. 107, No. GT9, September 1981, pp. 1233-1254.

Knightly, D., Nedwell, D.B., and Cooper M., "Capacity for Methane Oxidation in Landfill Cover Soils Measured in Laboratory-Scale Soil Microcosms", *Applied and Environmental Microbiology*, Volume 61, 1995, pp. 592-601.

NRC, *"Radon Attenuation Handbook for Uranium Mill Tailings Cover System"*, NUREG/CR-3533, prepared by Rogers and Associates Engineering, Salt Lake City, Utah, for the U.S. Nuclear Regulatory Commission, Washington, D.C., 1984.

Sims, J.L., Sims, R.C., and Matthews, J.E., *Bioremediation of Contaminated Surface Soils*, EPA/600/9-89/073, Robert Kerr Environmental Research Laboratory, August, 1989.

State of Ohio, Department of Transportation (ODOT), "*Construction of Materials Specifications*," Columbus, OH, January 1993.

Thorneloe, S., Barlaz, M., Peer, R., Huff, L., Davis, L., and Mangino, J., "Waste Management", *Atmospheric Methane: Sources, Sinks, and Role in Global Change*, Report No. EPA/600/A-94/090, U.S. Environmental Protection Agency, Research Triangle Park, NC, 1993, pp. 362-398.

U.S. Environmental Protection Agency (USEPA), *"Air Emissions from Municipal Solid Waste Landfills • Background Information for Proposed Standards and Guidelines"*, Report No. EPA-450/3-90-011a, U.S. Environmental Protection Agency, Research Triangle Park, NC, March 1991.

3. PROJECT DELIVERABLES

3.1 General Requirements

3.1.1 Introduction

The purpose of this section of the DCP is to identify administrative and substantive requirements for preparation and issuance of project deliverables for this design package. Section 3.1 addresses general administrative requirements. Substantive requirements are addressed in Section 3.2. Required deliverables for other design packages being developed as part of the integrated FEMP remediation are not addressed in this DCP. These other deliverables will be addressed in other appropriate DCPs. The requirements described in this section could change slightly based on the specifics of the OSDF detailed design.

3.1.2 Reports

Reports that will be prepared for this design package are identified in Section 1.6 of this DCP and described in more detail in Section 3.2. The reports must be prepared using Microsoft Word or compatible word processing program and should be submitted both in bound (i.e., assembled and bound in three-ring binders) and unbound, reproducible (i.e., "camera-ready") format. Any spreadsheets that are included in the reports should be prepared in a format compatible with Microsoft Excel software. Reports for regulatory submittal should be prepared in sets of 20 bound copies, plus an unbound copy for reproduction.

3.1.3 Calculations

Calculations should be submitted with the preliminary, intermediate, prefinal, final, and CFC design packages. A list of calculations to be prepared for the OSDF project is presented in Table 1-1 of this DCP (see pages 1-17 through 1-19). Spreadsheets that are submitted with calculations should be prepared in a format compatible with Microsoft Excel software. Calculations for regulatory submittal should be prepared in 20 bound copies, plus an unbound copy for reproduction.

3.1.4 Drawings

Drawings should be compiled using computer-aided design (CAD) techniques using a system compatible with Microstation Version 5.0 software. An anticipated list of OSDF CFC Drawings is presented in Table 1-2 of this DCP (see pages 1-18 through 1-21). As noted in Section 1.6 of this DCP, drawings that primarily present construction details and contractor instructions need not be included in the submittals for regulatory review.

OSDF drawings should be prepared on full size (i.e., 30 in. by 42 in.) and reduced (i.e., 11 in. × 17 in.) sheets. Full-size drawings intended for submittal to regulatory agencies should be printed on both mylar and bond media. Each drawing should be sequentially numbered with a fully-executed title block. Revision blocks should be prepared for each revision to reflect changes to the drawings. After the prefinal submittal, changes made to the drawings should be shown by "clouding" the area that is revised and making a keynote in the revision block; if this method of revision comprises the clarity of the drawings, then the drawing should be replaced and reissued. Drawings should be submitted with the preliminary, intermediate, prefinal, final, and CFC design packages. Drawings for regulatory submittal should be prepared in 20 bound copies, plus an unbound copy for reproduction.

3.1.5 Specifications

Specifications should be submitted with the preliminary, intermediate, prefinal, final, and CFC design packages. An anticipated list of OSDF CFC Specifications is presented in Table 1-3 (see page 1-22 and 1-23). As noted in Section 1.6 of this DCP, specifications that primarily address construction details and contractor instructions need not be included in the submittals for regulatory review.

OSDF specifications should be prepared using the standard Construction Specifications Institute (CSI) format for each construction activity. Specifications should provide sufficient detail to control the quality of construction materials and activities, while encouraging competitive procurement of materials and services. Specifications should be prepared using Microsoft Word format. Specification for regulatory submittal should be prepared in 20 bound copies, plus an unbound copy for reproduction.

3.1.6 Cost Estimates

Cost estimates should be prepared for OSDF construction, filling, and closure, for implementation of the test pad program, and for implementation of the leachate/liner compatibility study. The cost estimates must be in Fluor Fernald, Inc. format. This format is illustrated by the Fluor Fernald, Inc. baseline OSDF cost estimate presented in Appendix E of this document. Cost estimate spreadsheets must be compatible with Microsoft Excel. Cost estimates for regulatory submittal should be prepared in 20 bound copies, plus an unbound copy for reproduction.

3.1.7 Value Engineering

A value engineering session will be conducted after the preliminary design package is prepared to identify and evaluate potential cost-effective design alternatives. The results of the value engineering session should be evaluated by the OSDF design team for incorporation into the OSDF design. This process should be documented and the results incorporated into the design no later than the prefinal design package submittal.

3.2 Description of Design Deliverables

3.2.1 Design Criteria Package

This DCP should be submitted concurrently with the various design package submittals. This DCP contains criteria for use in the design of the OSDF and support facilities identified in this document. The DCP should be updated throughout the project as new or additional design criteria or design methods are identified and adopted. Updating should be carried out as described in Section 1.7 of this DCP.

3.2.2 Calculations, Drawings, and Specifications

As discussed in Section 1.2.2 of this DCP, the design deliverables include preliminary, intermediate, prefinal, final, and CFC design packages. Each design package will contain calculations, drawings, and specifications.

Calculations

Calculations should be prepared for the purpose of establishing the design of the OSDF and confirming that the design criteria contained in this DCP are met. Calculations should be prepared as indicated in Section 3.1.3 of this DCP.

Drawings

Drawings should be prepared in a manner that fully and clearly presents the materials and work activities required of the OSDF construction contractor to construct, fill, and close the OSDF. Drawings should be prepared as indicated in Section 3.1.4 of this DCP.

Specifications

Specifications should be prepared for the purpose of defining the OSDF construction contractor's responsibilities and duties, acceptable materials of construction, and standards for acceptable work. The specifications should address construction, filling, and closure of the OSDF, and construction, operation, and maintenance of appropriate support facilities. The specifications are to be prepared in standard CSI format and should generally contain the sections listed below (note: all second level headings need not be used). Specifications should be prepared as indicated in Section 3.1.5.

PART 1 GENERAL	PART 2 PRODUCTS	PART 3 EXECUTION
Summary	Materials	Examination
References	Manufactured Units	Preparation
Safety Requirements		Safety Requirements
Definitions	Equipment	Erection Installation Application
System Description	Components	Field Quality Control
Submittals	Accessories	Adjusting
Quality Assurance	Mixes	Cleaning
Delivery, Storage, and Handling	Fabrication	Demonstration
Project/Site Conditions	Source Quality Control	Protection
Sequencing and Scheduling		Schedules
Warranty		
Maintenance		

3.2.3 Leachate/Liner Compatibility Study Work Plan Report

A *Leachate/Liner Compatibility Study Work Plan* should be developed to describe a proposed leachate/liner compatibility study to be performed in accordance with the requirements of Section 2.4.6 of this DCP. A draft of the work plan should first be submitted to DOE, USEPA, and OEPA for review, comment, and approval. A final work plan should then be prepared and issued. A *Leachate/Liner Compatibility Study Report* should be prepared that contains the results of the leachate/liner compatibility study. The report should describe the work performed to evaluate the durability and chemical compatibility characteristics of the geomembrane liner and final cover system components of the OSDF. The report should also contain conclusions and recommendations for use in selecting and specifying the geomembrane components of the OSDF.

3.2.4 Soil Liner Test Pad Program Report

A *Soil Liner Test Pad Work Plan* should be prepared to implement the requirements of Section 2.7 of the DCP. The work plan should first be submitted in draft form for DOE, USEPA, and OEPA review, comment, and approval. A final work plan should then be prepared and issued. The results of the soil liner test pad program should be analyzed and presented in a *Soil Liner Test Pad Program Report*. The report should describe the procedures used in the test pad evaluation, the procedures used to analyze the field and laboratory test data, and the conclusions of the program. The report should contain: (i) recommendations regarding the suitability of the borrow sources for use as compacted clay liner and cap material; (ii) requirements for borrow source processing; and (iii) recommended criteria for compacted clay liner and cap construction.

3.2.5 Soil-Geosynthetic Interface Testing Report

A *Soil-Geosynthetic Interface Testing Work Plan* should be prepared to establish the interface testing needed to establish the OSDF liner system and final cover system design. This work plan should be submitted in draft form for DOE review, comment, and approval. A final work plan should then be prepared and issued. A *Soil-Geosynthetic Interface Testing Report* should be prepared to present the results of the laboratory direct shear testing program to evaluate the shear strengths of soil-geosynthetic and geosynthetic-geosynthetic interfaces that will exist in the OSDF liner and final cover systems. The report should describe the materials tested, the test procedures followed, and the results obtained. The report should also contain conclusions and recommendations on interface shear strengths to use in the design of the OSDF liner and final cover systems.

3.2.6 Project Support Plans

3.2.6.1 Construction Quality Assurance Plan

A *Construction Quality Assurance (CQA) Plan* should be prepared to describe the quality assurance monitoring, testing, documentation, and nonconformance resolution activities that will be undertaken during construction, filling, and closure of the OSDF. The *CQA Plan* should address both material and construction method conformance with the requirements of the specifications, appropriate regulatory requirements and guidance, and good construction practice. It is anticipated that these activities will be undertaken by OSDF A/E quality assurance personnel. The *CQA Plan* should be developed to conform to OEPA requirements (ARAR: OAC 3745-27-08(F)) and to relevant USEPA guidance. The plan should address, at a minimum:

- CQA project organization and personnel qualification requirements;
- documentation requirements;
- conformance surveying;
- soils CQA;
- geosynthetics CQA;
- valve houses, pipes, fittings, and valves CQA;
- electrical/mechanical equipment CQA; and
- cast-in-place concrete CQA.

It is noted that OSDF contractor construction quality control (CQC) requirements are addressed in the OSDF specifications.

The *CQA Plan* should first be prepared in draft form for DOE, USEPA, and OEPA review, comment, and approval. The draft plan should be submitted with the OSDF intermediate design package. A final CQA plan should then be prepared and issued with the OSDF prefinal design package.

3.2.6.2 Impacted Materials Placement Plan

An *Impacted Materials Placement Plan* should be prepared to describe procedures to be followed by the OSDF construction contractor for handling impacted material within the battery limit and placing the material in the OSDF. The plan is intended for use by the OSDF construction contractor during construction, filling, and closure of the OSDF. The plan should augment the specifications for impacted material handling and placement. The plan should be developed to provide flexibility to the OSDF construction contractor in selecting efficient and cost-effective equipment and material placement procedures.

The *Impacted Materials Placement Plan* should define the following:

- expected types and allowable dimensions of impacted material;
- required preparation procedures and measures for impacted material (with particular attention to procedures required for placement of solid waste, lime sludge, and building debris);
- impacted material handling and transport procedures within the battery limit;
- protection of the liner system and other engineered components of the OSDF;
- impacted material placement procedures and methods;
- procedures for leachate and surface-water control in active cells;
- procedures to control fugitive emissions (primarily dust);
- procedures for seasonal (winter) closure and other short-term closure due to inclement weather;
- quality assurance and quality control procedures for impacted material placement activities (including quality assurance checks that incoming waste meets the waste acceptance criteria (WAC)); and
- documentation and records of impacted material placement.

The *Impacted Materials Placement Plan* should first be prepared in draft form for DOE, USEPA, and OEPA review, comment, and approval. The draft plan should be submitted with the OSDF intermediate design package. A final plan should then be prepared and issued with the OSDF prefinal design package.

3.2.6.3 Impacted Material Quality Assurance Plan

An *Impacted Material Quality Assurance Plan* should be prepared as a stand alone document or as a component to the *Impacted Materials Placement Plan.* It is anticipated that the plan will be implemented by OSDF CQC Consultant personnel. The plan should address the quality assurance requirements for impacted material placement. The plan should include:

- monitoring and documentation activities to confirm that impacted materials disposed in the OSDF meet the OSDF WAC;
- monitoring and documentation activities to confirm that impacted materials disposed in the OSDF meet physical criteria for such disposal;
- manifesting requirements for impacted materials destined for the OSDF;
- waste acceptance quality assurance personnel qualification requirements; and
- recordkeeping requirements.

The *Impacted Materials Quality Assurance Plan* should first be prepared in draft form for DOE, USEPA, and OEPA review, comment, and approval. The draft plan should be submitted with the OSDF intermediate design package. A final plan should then be prepared and issued with the OSDF prefinal design package.

3.2.6.4 Surface-Water Management and Erosion Control Plan

A *Surface-Water Management and Erosion Control Plan* should be prepared to describe the procedures to be followed within the battery limit to control surface-water runon and runoff, minimize erosion, and minimize off-site sedimentation. The plan should be prepared for use by the OSDF construction contractor during construction, filling, and closure of the OSDF. The plan should be prepared in a manner that allows reasonable flexibility to the OSDF construction contractor in managing surface-water at the site.

The Surface-Water Management and Erosion Control Plan should address at least the following:

- relevant surface-water management regulatory requirements and standards;
- OSDF design drawings and specifications relevant to surface-water management and erosion and sediment control;
- procedures to be used to manage and control runon from off-site;
- procedures to be used to manage runoff from within the battery limit;
- procedures for erosion and sediment control;
- maintenance practices for sediment basins;
- criteria for installing and removing surface-water control and erosion protection facilities; and
- discharge criteria for water to be released from the battery limit.

The *Surface Water Management and Erosion Control Plan* should first be prepared in draft form for DOE, USEPA, and OEPA review, comment, and approval. The draft plan should be submitted with the OSDF intermediate design package. A final plan should then be prepared and issued with the OSDF prefinal design package.

3.2.6.5 Borrow Area Management and Restoration Plan

A *Borrow Area Management and Restoration Plan* should be prepared to describe the procedures to be followed in developing and restoring the on-site borrow area. The plan is intended for use by the OSDF construction contractor during development and restoration of the borrow area. The plan should be prepared to augment the drawings and specifications and should incorporate relevant criteria from this DCP. The plan should cross reference the *Surface Water Management and Erosion Control Plan* for borrow area surface-water management and erosion control requirements and procedures.

The *Borrow Area Management and Restoration Plan* should contain information on at least the following aspects of borrow area development and restoration:

- layout;
- phasing;
- borrow area clearing;
- excavation procedures;
- surface-water management;
- erosion and sediment control;
- removal and management of impacted material (if any);
- stockpiling of topsoil and unsuitable borrow material; and
- borrow area restoration.

The location, layout, and phasing of the on-site borrow area should be shown on the design drawings. Results of field and laboratory testing of materials in the borrow area should be provided and summarized in tabular or graphical form in the plan.

The *Borrow Area Management and Restoration Plan* should first be prepared in draft form for DOE, USEPA, and OEPA review comment, and approval. The draft plan should be submitted with the OSDF intermediate design package. A final plan should then be prepared and issued with the OSDF prefinal design package.

3.2.6.6 Systems Plan

A *Systems Plan* should be prepared to describe the operations, monitoring, and maintenance activities to be performed during filling and closure of the OSDF, and by the appropriate responsible party after closure. The plan should be prepared to augment the drawings and specifications and should incorporate relevant criteria from this DCP.

The *Systems Plan* should contain operational, monitoring, and maintenance requirements for at least the following OSDF engineered systems:

- leachate collection system;
- leak detection system;
- leachate transmission system;
- electrical/mechanical equipment;
- final cover system; and
- ancillary facilities.

Operational, monitoring, and maintenance requirements for the surface-water management and erosion control systems will be covered in the *Surface Water Management and Erosion Control Plan*. The *System Plan* should cross reference these other requirements. The *Systems Plan* should also describe the response actions to be taken if flows from the leak detection system drain pipe for a cell exceed the action leakage rate (ALR).

The *Systems Plan* should first be prepared in draft form for DOE, USEPA, and OEPA review, comment, and approval. The draft plan should be submitted with the OSDF intermediate design package. A final plan should then be prepared and issued with the OSDF prefinal design package. During construction of the OSDF, the *Systems Plan* should be updated and expanded to contain equipment manuals and operating and maintenance procedures for the specific equipment and systems procured and installed by the OSDF construction contractor.

3.2.6.7 Environmental Air Monitoring Plan

An Environmental *Air Monitoring Plan* should be prepared to establish the requirements, and describe the procedures, for monitoring air quality around the OSDF during construction, filling, and closure of the OSDF. The plan should address requirements for:

- air monitoring locations and frequencies;
- air monitoring equipment;
- data interpretation and recordkeeping;
- quality assurance requirements; and
- air monitoring personnel qualification requirements.

The Environmental *Air Monitoring Plan* should first be prepared in draft form for DOE, USEPA, and OEPA review, comment, and approval. The draft plan should be submitted with the OSDF intermediate design package. A final plan should then be prepared and issued with the OSDF prefinal design package.

3.2.7 Cost Estimates

A construction cost estimate must be prepared for the OSDF project. The cost estimate should include a detailed breakdown of material and construction quantities and a derivation of estimated unit costs for each element of construction. The unit costs should be presented in units similar to the proposed contract payment basis (e.g., time and material costs estimates should be prepared for items to be paid on a time and material basis). Construction cost estimates should be developed after preparation of the preliminary, prefinal, and final design packages. Cost estimates should also be prepared for implementation of the liner compatibility study and the soil liner test pad program, as described in Sections 2.4.9 and 2.7.7, respectively, of this DCP.

3.2.8 Value Engineering Documentation

The value engineering session results should be documented in a manner that describes which value engineering concepts were incorporated into the design and which were not. Value engineering documentation should be prepared after completion and submittal of the prefinal design package.

3.2.9 Design Documentation

Design documentation should be prepared to document the manner in which the OSDF final design package satisfies all of the design criteria enumerated in this DCP. Design documentation should have an organization consistent with the organization of this DCP. Design documentation should be prepared after completion and submittal of the final design package.

3.2.10 Response Documents

Written responses must be prepared for all formal comments on project deliverables received from DOE and the regulatory agencies (OEPA and USEPA). Response documents are anticipated for the following:

- Design Criteria Package;
- Test Pad Work Plan;
- Liner Compatibility Study Work Plan;
- Preliminary Design Package;
- Intermediate Design Package;
- Prefinal Design Package;
- Final Design Package; and
- Project Work Plans.

APPENDIX A

APPENDIX A

OPERABLE UNIT 2 RECORD OF DECISION (SECTIONS 9 AND 10)

No Changes to Appendix

Appendix A not included with this Distribution

APPENDIX B

APPENDIX B

DRAFT DETAILED FACILITY DESCRIPTION/FUNCTIONAL REQUIREMENTS

No Changes to Appendix

Appendix B not included with this Distribution

APPENDIX C

APPENDIX C

ARARs FOR OPERABLE UNIT 2

No Changes to Appendix

Appendix C not included with this Distribution

APPENDIX D

APPENDIX D

ARARs FOR OPERABLE UNIT 5

No Changes to Appendix

Appendix D not included with this Distribution

APPENDIX E

APPENDIX E

FLUOR FERNALD, INC. BASELINE OSDF COST ESTIMATE

No Changes to Appendix

Appendix E not included with this Distribution