Attachment C

Groundwater/Leak Detection and Leachate Monitoring Plan

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Contents

Figures

Tables

Appendixes

Abbreviations

ANOVA	analysis of variance
ARARs	applicable or relevant and appropriate requirements
CAWWT	converted advanced wastewater treatment facility
CFR	*Code of Federal Regulations*
cm/s	centimeters per second
CUSUM	cumulative sum
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FRL	final remediation level
ft	foot/feet
GMA	Great Miami Aquifer
GO/UGMAS	Glacial Overburden/Upper Great Miami Aquifer System Report
gpad	gallons per acre per day
gpm	gallons per minute
GWLMP	*Groundwater/Leak Detection and Leachate Monitoring Plan*
HDPE	high-density polyethylene
HTW	horizontal till well
IEMP	Integrated Environmental Monitoring Plan
K_d	distribution coefficient
K_l	leaching coefficient
K_v	vertical hydraulic conductivity
LCS	leachate collection system
LDS	leak detection system
LTS	leachate transmission system
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mL	milliliters
NPDES	National Pollutant Discharge Elimination System
OAC	*Ohio Administrative Code*
OSDF	On-Site Disposal Facility
OU	Operable Unit
PCBs	polychorinated biphenyls

PLS	permanent lift station
RA	remedial action
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
SWIFT	Sandia Waste Isolation Flow and Transport
TDS	total dissolved solids
UMTRCA	Uranium Mill Tailings Radiation Control Act
VAM3D	Variably Saturated Analysis Model in 3 Dimensions
WAC	waste acceptance criteria

1.0 Introduction

This document presents the *Groundwater/Leak Detection and Leachate Monitoring Plan* (GWLMP) for the On-Site Disposal Facility (OSDF) at the U.S. Department of Energy's (DOE's) Fernald Preserve. The GWLMP is a support plan for the OSDF, and it is required by the *Remedial Action* (RA) *Work Plan for the On-Site Disposal Facility* (DOE 1996a). Revision 0 of the GWLMP was issued in August 1997 (DOE 1997), Revision 1 was issued in April 2005 (DOE 2005), and draft final Revision 2 was issued in January 2006 (DOE 2006). The GWLMP is integrated into the *Comprehensive Legacy Management and Institutional Controls Plan.*

The DOE Office of Legacy Management is responsible for OSDF monitoring, maintenance, and reporting. The GWLMP will be revised, as necessary, to reflect approved updates to monitoring and reporting requirements and will continue to be used through the post-closure period.

The GWLMP was developed to meet the regulatory requirements for the first tier of a three-tiered monitoring strategy required for engineered disposal facilities (i.e., [1] detection, [2] assessment, and [3] corrective action monitoring strategy). Consistent with this three-tiered requirement, follow-up groundwater quality assessment and corrective action monitoring plans will be developed and implemented as necessary.

The monitoring program comprises two primary components: (1) a leak detection component, which provides information to verify the ongoing performance and integrity of the OSDF and its impact on groundwater, and (2) a leachate monitoring component, which satisfies regulatory requirements for leachate collection and management. Two groundwater zones are monitored beneath the OSDF: the Great Miami Aquifer (GMA) (a water table found at depths ranging from 40 to 90 feet [ft] below ground surface near the OSDF) and the perched groundwater in the glacial till overlying the GMA.

The OSDF is an engineered disposal cell. As such, it is unlikely that a leak would occur without a corresponding action leakage rate, but significant changes in either water quality and/or flow rates will be investigated. Monitoring for a leak from the OSDF using water-quality data alone is challenging in that:

- The low-permeability clay beneath the facility does not readily transmit water.
- Near the OSDF, contaminant concentrations exceed background levels in surface and subsurface soil, in perched groundwater in the glacial till, and in the GMA.
- Post-construction geochemistry and constituent concentrations in water beneath the OSDF have not reached steady-state conditions, and these fluctuations complicate data interpretations.
- There is evidence that at least one of the horizontal till wells (HTWs) is in hydraulic communication with a surface water drainage ditch on the west side of the OSDF.

Table 1 provides a summary of key monitoring parameters.

Table 1. Facility Performance Key Monitoring Parameters

Parameter Type	Parameter Description	Basis	Monitoring Frequency	Action Level[a]	Action Level Units[a]	Regulatory Status[b]
Flow Volume[d]	LDS[c] Flow Volume	Each Cell	Daily	20	gpad[d]	Approved
	LCS Flow Volume	Each Cell	Daily	NA	NA	Approved
	LCS Containment Pipe Monitoring	Each Cell	Monthly	2,270	mL[e]	Approved
	LDS Containment Pipe Monitoring	Each Cell	Monthly	2,650	mL	Approved
	Redundant Leachate Collection System Containment Pipe Monitoring	Each Cell	Monthly	2,650	mL	Approved
	LTS[f] in each Valve House (PS-1 through 7)	Each Cell	Monthly	5,300	mL	Approved
	LTS at Port V1007 (PS-9)		Monthly	18,900	mL	Approved
	LTS at Port V1006 (PS-10)		Monthly	370	mL	Approved
Water Quality	LCS aqueous sample analysis for parameters listed in Table 1 of Appendix B.	Each Cell	Annual	NA	NA	Approved
	LCS, LDS, GMA aqueous sample analysis for parameters listed in Table 2 of Appendix B.	Each Cell	Semiannual	NA	NA	Approved
	HTW aqueous sample analysis for parameters listed in Table 3 of Appendix B.	Each Cell	Semiannual	NA	NA	Approved

[a] NA = not applicable
[b] Regulatory status (regarding description, basis, frequency, and action level) as of the time the plan was submitted for EPA/Ohio EPA review (e.g., "proposed" or "approved")
[c] LDS = leak detection system
[d] gpad = gallons per acre per day
[e] mL = milliliters
[f] LTS = leachate transmission system

1.1 Overview of the OSDF

The OSDF is located along the northeast portion of the Fernald Preserve and, as required by the Operable Unit (OU) 2, OU3, and OU5 Records of Decision (RODs), is situated over the “best available geology” at the Fernald Preserve to take maximum advantage of the protective hydrogeologic features of the glacial till above the GMA. The footprint of the actual disposal facility is approximately 75 acres. A perimeter security fence surrounds the OSDF and defines a footprint that occupies approximately 98 acres of the 1,050 acre Fernald Preserve. The 98 acre fenced area is dedicated to disposal and will remain under federal ownership and federal administrative control now that the Fernald Preserve’s cleanup mission has been completed.

The OSDF provides onsite disposal capacity for approximately 2.96 million cubic yards of contaminated soil and debris generated by the Fernald Preserve’s environmental restoration and building decontamination and demolition activities. The OSDF has a maximum height of approximately 65 ft. The facility was constructed in phases, with eight individual cells. Cells are approximately 700 ft by 400 ft, or 280,000 square ft (ft^2) (6.4 acres). The dimensions of Cell 8 are larger than those of the other cells (approximately 9.4 acres). Each cell was constructed with a leachate collection system (LCS) that collected infiltrating rainwater and storm water runoff during waste placement and prevented it from entering the underlying environment. Other engineered features include a multilayer composite liner system, a leak detection system (LDS) positioned beneath the primary liner, and a multilayer composite cover placed over each cell following the completion of waste-placement activities.

Figure 1 shows an east-west cross-section of the general design of each of the eight disposal cells in the facility. The LCS and LDS layers are designed to convey any leachate/fluid that enters the system through pipes (i.e., the LCS pipes and LDS pipes) to the west side of each cell to a liner-penetration box. The liner-penetration box is the point where the LCS and LDS pipes penetrate the liner system and therefore represents the lowest elevation of each cell and the most likely point for a leak to occur. From the liner-penetration box, the LCS and LDS pipes drain to valve houses where the leachate and LDS fluid are collected in tanks, flow rates and volumes are monitored, and samples are collected. Fluid that collects in the LCS and LDS collection tanks located in each cell's valve house is pumped to the gravity drain portion of the leachate transmission system line, which drains all valve houses to the permanent lift station (PLS). The leachate collected in the PLS is periodically pumped to the Converted Advanced Wastewater Treatment facility (CAWWT) backwash basin or directly to CAWWT feed tanks. The Enhanced Permanent Leachate Transmission System consists of the valve houses and the equipment contained within them as well as the gravity drain portion of the leachate transmission line that runs from the valve house at Cell 1 to the PLS. Figure 2 depicts a cross section of the liner system.

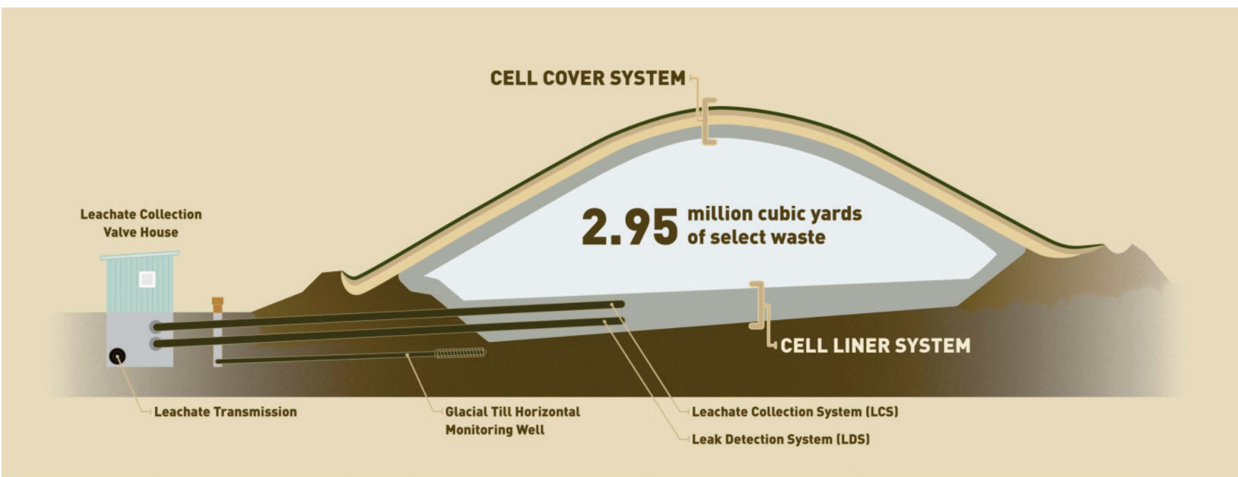

Figure 1. OSDF Cross Section

During the development of this plan, the U.S. Environmental Protection Agency (EPA) and the Ohio Environmental Protection Agency (Ohio EPA) identified the need to monitor the potential for leachate leakage from the OSDF at its first point of entry into the natural hydrogeologic environment (rather than relying on GMA groundwater monitoring alone). This led to the decision to install horizontal monitoring wells in the glacial till directly beneath the liner-penetration boxes of the LCS and LDS layers in each cell. Figure 1 shows the general placement of the horizontal wells in relation to the LCS, LDS, and where they penetrate the liner system. The subsurface area beneath the liner-penetration boxes provides the best opportunity to monitor for an initial leak into the subsurface environment, should such a leak occur.

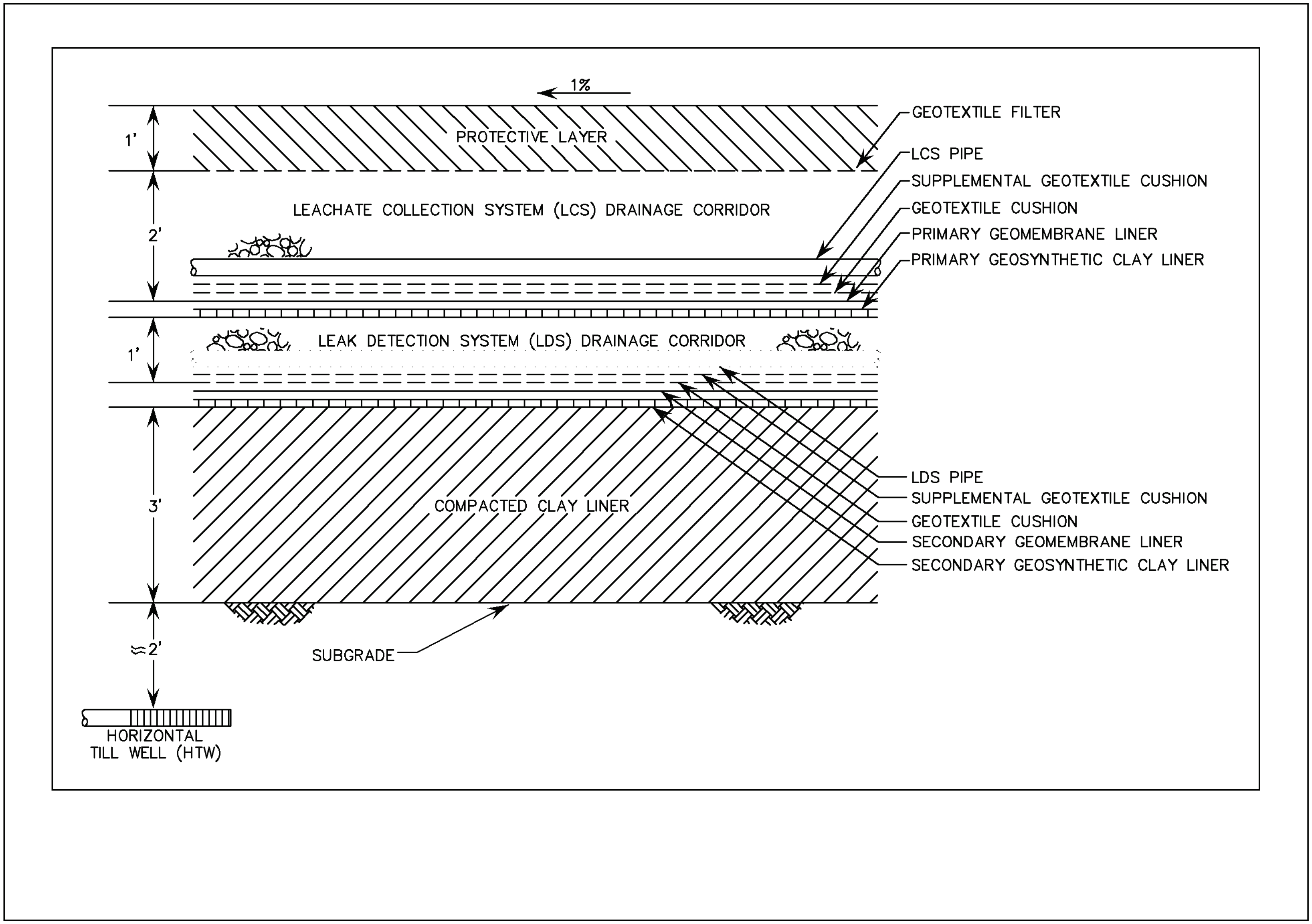

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Figure 2. OSDF Liner System with HTW at the Drainage Corridor

As a result of the low transmissive properties of the glacial till and the discontinuous nature of the perched groundwater system in the till, it is not always possible to collect groundwater samples routinely from the horizontal wells. In view of this limitation, DOE, EPA, and Ohio EPA concurred that the placement of the horizontal wells beneath the liner-penetration boxes represents the most feasible site-specific approach to monitor for first entry leakage from the facility to the environment, and this approach provides adequate and appropriate early warning detection capabilities for this site-specific setting.

An important design specification for the OSDF is the action leakage rate. The action leakage rate is the maximum design flow rate that the LDS can remove without the fluid head on the bottom liner exceeding 1 ft (Title 40 *Code of Federal Regulations* Part 264.302 [40 CFR 264.302]). Stated in another way, it is the flow rate that corresponds to a hydraulic head within the facility capable of producing a leak through the compacted clay layer that is present at the base of the facility. The OSDF has an action leakage rate of 200 gallons per acre per day (gpad) (DOE 1997).

DOE will not wait until the action leakage rate is reached to investigate the possibility of a leak from the facility. To be conservative, an administrative control called the "initial response leakage rate" has been defined for the OSDF as 1/10 of the action leakage rate (i.e., 20 gpad). If the initial response leakage rate of 20 gpad is measured in the LDS, DOE will begin the process of determining the cause of the increased flow and will evaluate the potential that a release from the LCS has occurred.

1.2 Program Overview

The GWLMP was developed by reviewing the pertinent regulatory requirements for detection monitoring and translating those requirements into site-specific monitoring elements (e.g., designation of monitoring zones, monitoring locations, sampling frequency, and establishment of analytical parameters).

The GWLMP considers current hydrogeologic and contaminant conditions in the glacial till and GMA beneath the facility. Preexisting contamination in the perched groundwater system and the GMA, the variable nature of the geology and hydrogeology of the clay-rich glacial deposits, and the influence of aquifer restoration activities in the GMA add complexity to the development of a groundwater monitoring program. Contaminated portions of the GMA were undergoing restoration during the same time period that the OSDF was actively accepting waste for disposal, after the facility was capped and during post-closure. The aquifer restoration is a pump-and-treat operation. The closest pumping wells are approximately 2,000 ft upgradient of the OSDF footprint.

Available site-specific information generated from more than 15 years of detailed site characterization efforts, including geology and hydrogeology, results of detailed contaminant fate and transport modeling, OSDF construction activities, and monitoring results from the OSDF program and Attachment D (Integrated Environmental Monitoring Plan [IEMP]) were used to develop the monitoring strategy and to determine monitoring locations.

The GWLMP focuses on the monitoring needs associated with detection monitoring during post-closure. Future amendments to the plan will be prepared to address program modifications, if changes to the monitoring program are necessary. An in-depth review of program needs is also envisioned at the completion of GMA restoration activities.

A brief description of the monitoring program is as follows:

- Flow volumes in the LDS are tracked against the initial response leakage rate of 20 gpad. Flow reaching an initial response leakage rate will be considered evidence that hydraulic conditions are 1/10 of the level needed to achieve the hydraulic head required to produce a possible leak from the OSDF. If measurements indicate an initial response leakage rate of 20 gpad, DOE will begin the process of determining the cause of the increased flow and will evaluate the potential that a release from the facility has occurred.
- Water quality in the LCS, LDS, HTW, and GMA wells of each cell is routinely monitored. Control charts are prepared for those constituents in the HTW and GMA wells that pass statistical screening for the preparation of control charts. Plots of concentration versus time are prepared for constituents in the HTW and GMA wells that do not pass statistical screening for the preparation of control charts. Bivariate plots for uranium-sodium are prepared for each cell. Other appropriate multi-parameter multivariate plots may be prepared if necessary to show independence of sampled horizons.

It should be noted that it is unlikely that a leak would occur without a corresponding action leakage rate, but significant changes in either water quality and/or flow rates will be investigated.

The OSDF groundwater monitoring plan has been implemented as a project-specific plan (refer to Appendix B), with the results presented for EPA and Ohio EPA review as part of the comprehensive IEMP reporting process (i.e., annual Site Environmental Reports). The IEMP provides a consolidated reporting mechanism for all of the environmental regulatory compliance monitoring activities, including the data and findings from the OSDF groundwater monitoring plan. Incorporating the OSDF data into the IEMP maintains the commitment to an effective remediation-focused environmental surveillance monitoring program. Once the environmental remediation requirements have been completed and the site is successfully removed from the Superfund National Priorities List, the monitoring activity for the OSDF (which will be the last remaining facility in place at the site) will continue in accordance with applicable regulatory monitoring and reporting requirements.

1.3 Plan Organization

The remainder of this plan is organized as follows:

- Section 2.0 presents a summary of the geology and hydrogeology in the immediate area of the OSDF.
- Section 3.0 presents a regulatory analysis and strategy for OSDF monitoring.
- Section 4.0 presents the OSDF leak detection monitoring program.
- Section 5.0 presents the OSDF leachate management monitoring program.
- Section 6.0 presents reporting requirements and notifications.
- Section 7.0 provides a list of references.

The appendixes that support this plan are:

- Appendix A—OSDF Applicable or Relevant and Appropriate Requirements (ARARs) and Other Regulatory Requirements.
- Appendix B—Project-Specific Plan for the On-Site Disposal Facility Monitoring Program.
- Appendix C—Fernald Preserve Data Quality Objectives, Monitoring Program for the On-Site Disposal Facility.
- Appendix D—Leachate Management System for the On-Site Disposal Facility.
- Appendix E—Selection Process for Site-Specific Leak Detection Indicator Parameters.

1.4 Related Plans

Several other RA plans have been prepared for the OSDF or for the Fernald Preserve as a whole, containing information relevant to this plan. They are listed below along with a brief statement of their relationship to this plan:

- *Pre-Design Investigation and Site Selection Report for the On-Site Disposal Facility* and addendum (DOE 1995a and DOE 1996b): Describe field activities used to assess potential sites for the OSDF, and present the information collected during addendum activities to the *Project-Specific Plan for Installation of the On-Site Disposal Facility Great Miami Aquifer Monitoring Wells* (DOE 2001a).
- OSDF Systems Plan (DOE 2001b): Describes the inspection and maintenance of the LCS and LDS.
- *Wastewater Treatment Outside Systems Procedure for the Fernald Preserve, Fernald, Ohio* (DOE 2014b) and the *Converted Advanced Wastewater Treatment Facility Procedure for the Fernald Preserve, Fernald, Ohio* (DOE 2014a): Are the operational procedures for management, inspection, and conveyance of leachate and fluid from the LCS and LDS.
- OSDF Design Packages (GeoSyntec 1996a, GeoSyntec 1996b, GeoSyntec 1997, DOE 2004a) and construction drawing packages: Provide the overall approved design for each cell of the OSDF.
- Post-Closure Care and Inspection Plan (Attachment B): Summarizes the inspection and maintenance activities (e.g., cap and runoff controls) to ensure continued proper performance of the OSDF and also summarizes at the conceptual level corrective actions/response actions.
- *Borrow Area Management and Restoration Plan, On-Site Disposal Facility* (GeoSyntec 2001a): Describes management of borrow soils used to construct the OSDF, and describes the planning for end state after soils have been excavated.
- *Surface Water Management and Erosion Control Plan, On-Site Disposal Facility* (GeoSyntec 2001b): Describes soil erosion control to minimize sediment loss.
- *Construction Quality Assurance Plan, On-Site Disposal Facility* (GeoSyntec 2002): Describes quality assurance methods and testing to certify the construction of the OSDF.
- *Impacted Materials Placement Plan, On-Site Disposal Facility* (GeoSyntec 2005): Describes the categories of material, prohibited items, and placement methods for impacted material placement in the cells.

- *Waste Acceptance Criteria Attainment Plan for the On-Site Disposal Facility* (DOE 1998a): Defines the OSDF requirements for materials generated by the Fernald Site's environmental restoration, and decontamination and demolition efforts.
- *Project-Specific Plan for Installation of the On-Site Disposal Facility Great Miami Aquifer Monitoring Wells* (DOE 2001a): Describes the installation of GMA wells.
- *Technical Memorandum for the On-Site Disposal Facility Cells 1, 2, and 3 Baseline Groundwater Conditions* (DOE 2002): Describes baseline conditions for Cells 1, 2, and 3.
- IEMP (Attachment D).
- Additionally, annual Site Environmental Reports include OSDF reporting requirement updates.

2.0 OSDF Area Geology and Hydrogeology

2.1 Introduction

The OU2, OU3, and OU5 RODs contain requirements that led to the OSDF being located in an area of the Fernald Preserve that takes maximum advantage of available geologic and hydrogeologic conditions to further reduce the potential for contaminant migration from the facility. To identify the preferred OSDF location, a detailed predesign geotechnical and hydrogeologic investigation was conducted as a supplement to the sitewide characterization efforts described in *Remedial Investigation Report for Operable Unit 5* (DOE 1995b). The detailed findings of the pre-design investigation are documented in the *Pre-Design Investigation and Site Selection Report for the On-Site Disposal Facility* (DOE 1995a). As documented in the site selection report, a final location along the eastern margin of the Fernald Preserve was selected to satisfy the RODs and other regulatory-based siting requirements.

The following sections summarize the principal geologic, hydrogeologic, and subsurface contaminant conditions in the OSDF area that have a direct bearing on the development of the leak detection and groundwater monitoring strategy for the facility. For more-detailed information, refer to the *Pre-Design Investigation and Site Selection Report for the On-Site Disposal Facility* (DOE 1995a) and *Remedial Investigation Report for Operable Unit 5* (DOE 1995b).

2.2 OSDF Area Geology

The perimeter security fence that surrounds the OSDF defines a 98 acre footprint in the northeastern corner of the Fernald Preserve. The facility is oriented in a north-south direction with dimensions of approximately 3,600 ft by 1,000 ft. The east edge of the facility (i.e., the toe of the cap system) is set back from the eastern property line by approximately 100 ft. The subsurface conditions in the immediate area of the OSDF were characterized through the following field and laboratory activities:

Test borings	Fifty-four borings were drilled in the immediate vicinity of the OSDF to obtain geotechnical soil samples and characterize underlying geology.
Monitoring wells	Fifty-one groundwater monitoring wells were installed in the general vicinity of the OSDF from which water level data, preexisting groundwater contaminant concentration data, and lithology data have been obtained.
Geotechnical tests	Key geotechnical tests (i.e., Atterberg limits, water content measurements, and permeability tests) were performed on subsurface geologic samples, including 116 sieve analyses to determine grain size.

Lysimeter installation	Eight lysimeters were installed in the OSDF site area to determine the nature and concentration of uranium in the vadose zone of the glacial till and the unsaturated GMA.
Slug tests	Twenty-four slug tests were performed to assess the hydraulic characteristics of the perched groundwater system.
Water level monitoring	Water levels obtained from the perched groundwater and the GMA wells were used to determine hydraulic gradients and flow directions.
Soil analyses	Soil samples collected during the remedial investigation (RI) and the Pre-Design Investigation were characterized for mineralogy and analyzed for uranium and other constituents of concern to determine preexisting contaminant levels in the soil beneath the OSDF.
Groundwater flowmeter study	Twenty-two flowmeter readings were obtained in the perched groundwater in the OSDF site area.
Distribution coefficient (K_d) study	A K_d study was performed to determine how uranium partitions between groundwater and soil in the OSDF site area.
Cone penetrometer tests	Eighty-eight cone penetrometer tests were conducted in the OSDF site area to aid in making subsurface lithologic interpretations.

The information obtained through these activities, coupled with the sitewide interpretations gained through the OU5 RI, formed the basis for the interpretations of subsurface conditions in the vicinity of the OSDF site.

In general, the OSDF is situated on glacial till underlain by sand and gravel deposits that comprise the GMA, which is designated as a sole-source aquifer under the Safe Drinking Water Act. The GMA is a high-yield aquifer (i.e., wells completed in some areas of the aquifer yield greater than 500 gallons per minute (gpm), and it supplies a significant amount of potable and industrial water to Butler and Hamilton Counties.

The glacial till ranges in thickness from approximately 20 to 60 ft in the immediate vicinity of the OSDF and is composed of about equal portions of carbonate (calcite and dolomite) and silicate (quartz, feldspar, and clay minerals) grains. Based on the results of 116 sieve and hydrometer analyses, the glacial till can be characterized as dense, heterogeneous, sandy, lean clay, with occasional discontinuous interbedded sand and gravel lenses. The glacial till can be further divided into an upper brown clay layer and a lower gray clay layer. This division is made on color and physical properties because the mineralogy is similar in both layers. The brown clay layer is more weathered (i.e., it exhibits iron oxidation and contains a greater abundance of desiccation fractures compared with the underlying gray clay layer) and has a higher incidence of interbedded sand and gravel lenses. In the eastern portions of the Fernald Preserve, the gray clay ranges in thickness from approximately 15 to 42 ft, and the brown clay ranges from approximately 8 to 15 ft. As indicated by the OU5 RI, the gray clay is the most uniform and least permeable and, therefore, the most protective geologic layer found above the GMA across the site.

As a follow-up to the OU5 RI, one of the primary objectives of the *Pre-Design Investigation and Site Selection Report for the On-Site Disposal Facility* (DOE 1995a) was to identify the location where the thickest, most laterally persistent gray clay layer is present that contains the least amount of interbedded coarse granular material, and that allows regulatory-based siting requirements (such as the property line and other geographic setbacks) to be met. The selected location for the OSDF has a minimum thickness of gray till of approximately 15 ft and an average thickness of approximately 30 ft. The percentage of interbedded sands and gravels in the gray till in this area is approximately 4 percent.

Beneath the glacial till layer, the sand and gravel deposits of the GMA are approximately 175 ft thick. For RI characterization and monitoring purposes, the GMA has been divided into three hydrologic zones: the uppermost zone, represented by the Fernald Preserve's Type 2 monitoring wells; the middle zone, represented by the Type 3 monitoring wells; and the lowermost zone, represented by the Type 4 monitoring wells. The sand and gravel deposits that constitute the aquifer are regionally extensive and occupy a land area of more than 970,000 acres.

Shale and limestone bedrock underlies the GMA deposits at a depth of approximately 200 ft beneath the OSDF. Regional studies by the Geological Survey of Ohio indicate the shale and limestone bedrock is approximately 330 ft thick in the Fernald Preserve area (Fenneman 1916).

2.3 Hydrogeologic Conditions

The Fernald Preserve has two distinct bodies of groundwater that have been extensively characterized through the remedial investigation/feasibility study (RI/FS) process and the Pre-Design Investigation: the GMA and the perched groundwater within the overlying glacial till. The discontinuous sand and sand and gravel lenses within the glacial till can provide water to a pumping well because the deposits are more permeable than the surrounding clay-rich glacial till. The entire section of glacial till is believed to be saturated or nearly saturated with groundwater. An unsaturated sand and gravel zone approximately 20 ft to 30 ft thick separates the base of the glacial till from the regional water table in the GMA. Depending on local weather patterns and rainfall, the water table in the GMA fluctuates approximately 6 ft annually within the unsaturated zone below the glacial till in the area of the OSDF.

The GMA is a classic example of an unconfined buried valley aquifer. The depth to water in the aquifer near the OSDF ranges from 40 to 90 ft below ground surface. The direction of groundwater flow beneath the OSDF is being temporarily influenced by the pump-and-treat remedy. Five years of water level measurements prior to operating the pump-and-treat system (1988 through 1993) indicate that groundwater flowed from the west to the east beneath the OSDF (refer to OU5 RI Report, Figure 3-50). The pump-and-treat system that is currently operating pulls groundwater in the area of the OSDF to the southwest. It will not be possible to establish a long term upgradient-downgradient monitoring relationship beneath the OSDF until the pump-and-treat remedy ends. The current early estimate for the completion of the pump and treat portion of the groundwater remedy is 2035. Groundwater velocity in the area of the OSDF is approximately 451 ft per year, based on an average hydraulic gradient of approximately 0.0008 (refer to OU5 RI, page 3–61); an average hydraulic conductivity of approximately 463 ft per day (average of three pumping tests); and an effective porosity of 30 percent. Geochemical processes influencing uranium distribution (i.e., rainfall/soil chemistry, leaching of uranium solids, oxidation-reduction reactions, adsorption and ion-exchange reactions, and uranium mineral solubility in perched groundwater) are presented in Section F.3.1.3.0 of Appendix F.3 of the *Remedial Investigation Report for Operable Unit 5* (DOE 1995b). Ranges for site-specific geochemical parameters are presented in Table F.3.1.5-1. As shown in Table F.3.1.5-1, the groundwater model was initially calibrated with a K_d of 1.8, which corresponds to a retardation factor of 12. At a retardation factor of 12, uranium moves approximately 1/12 as fast as the groundwater, or approximately 37.6 ft per year. Studies conducted by Sandia National Laboratories on uranium-contaminated sediment collected from the vadose zone indicate that the K_d ranges from 2.8 to 8.7 (SNL 2003, SNL 2004). The higher K_d values reported for the Sandia study reflect natural variability in the aquifer and stronger bonding of the adsorbed uranium as it ages on the mineral surface, which results in a higher retardation factor and indicates slower migration times. Uranyl carbonate is the dominate phase in both perched groundwater and the GMA near the Fernald Preserve.

Perched groundwater is present above the unsaturated zone of the GMA within the glacial till. Overall, the till exhibits 90 to 100 percent saturation (close to field capacity) and has the general properties of an aquitard. When the till reaches field capacity, it has the capability to release groundwater downward under a unit vertical hydraulic gradient into the underlying unsaturated zone of the GMA. Eventually, this downward-moving groundwater will enter the saturated portion of the GMA as recharge. Depths to perched groundwater in the till are generally 6 ft or less in the eastern portion of the Fernald Preserve in the area of the OSDF.

Although the till is generally saturated, there are no identified suitably thick or laterally continuous coarse-grained zones beneath the OSDF that can facilitate implementation of a comprehensive, interlinked (i.e., upgradient and downgradient monitoring points) perched groundwater monitoring system. The amount of saturation in the till is expected to be reduced even further over time since the cap and underlying liners of the OSDF are in place; they are serving as local hydraulic barriers to further reduce the volume of infiltrating moisture within the OSDF footprint.

Slug test data from 24 perched groundwater wells (Type 1 monitoring wells) indicate that the average horizontal hydraulic conductivity for wells screened across the brown and gray clay layer interface is 6.30×10^{-6} centimeters per second (cm/s). The gray clay layer beneath the brown clay is the least permeable layer above the GMA. Laboratory hydraulic conductivities conducted on samples collected from this layer indicate measured values ranging from 9.53×10^{-9} cm/s to 5.83×10^{-8} cm/s. Other laboratory and field measurements indicate the till has an effective porosity of 4 to 10 percent, and a representative bulk density of 1.85 grams per cubic centimeter. The discontinuous nature of the perched water in the glacial till does not facilitate the measurement of a continuous water table gradient in the OSDF site area.

Model calibration studies conducted during the OU5 RI/FS indicate average vertical groundwater flow rates through the glacial till (including the gray clay layer) to be approximately 6 inches per year. The time it takes a contaminant to move through the glacial till and break through into the GMA is controlled by the thickness of gray clay present in the till, the groundwater infiltration rate through the gray clay, and the retardation properties of the gray clay. In the OSDF area, modeled breakthrough travel times for uranium (the Fernald Preserve's predominant contaminant) range from approximately 210 years (to have a 20-micrograms-per-liter concentration in the aquifer) to 260 years (to have 1 percent of the source concentration). These breakthrough times were calculated using a retardation factor of 165 for the gray clay, not considering movement through the brown clay, not including any retardation in the unsaturated GMA sand and gravel, and using a representative K_v value of 7.23E-07 cm/s for the gray clay (refer to Appendix F of the *Remedial Investigation Report for Operable Unit 5* [DOE 1995b]). The K_v for the gray clay was determined from modeling presented in the *Glacial Overburden/Upper Great Miami Aquifer System Report* ([GO/UGMAS] DOE 1994) and from slug test results from the gray clay.

The modeled breakthrough travel time for 1 percent of a technetium source, the Fernald Preserve's most mobile contaminant, is approximately 3.6 years. This breakthrough time was calculated using a retardation factor of 2.29 for the gray clay (refer to OU5 RI report, Appendix F [DOE 1995b]), not considering movement through the brown clay, and not including any retardation in the unsaturated GMA sand and gravel. This modeling strategy was used in the OU5 Feasibility Study (DOE 1995d) to calculate waste acceptance criteria (WAC) for the OSDF.

The extensive presence of low-permeability, lean sandy clay throughout the till matrix and the discontinuous nature of the coarser-grained lenses are the dominant factors controlling the rate at which fluids can migrate through the more permeable portions of till, either vertically or laterally.

Unlike conditions in the GMA, the upgradient and downgradient directions of perched groundwater flow are difficult to assign at the local scale. Groundwater flowmeter readings from 22 wells taken during the Pre-Design Investigation indicate that the horizontal flow directions vary abruptly from well to well, with no discernable consistent patterns. Consequently, horizontal flow regimes are interpreted to be very localized (perhaps tens to hundreds of feet in length) and, because the interbedded coarse-grained lenses are discontinuous, are not laterally persistent. Collectively, the water levels obtained during the OU5 RI indicate that if an area gradient were present, it would range from 0.008 to 0.015.

Model calibration studies conducted during the OU5 RI/FS indicate that vertical flow tends to dominate in the glacial till because of several factors: (1) the steep vertical hydraulic gradients across the till—which are at or near unity—compared to the small localized lateral hydraulic gradients, which collectively indicate a gradient that is much less than unity (0.008 to 0.015); (2) the laterally discontinuous nature of the coarse-grained lenses in the till; and (3) the shorter overall flowpath distance in the vertical dimension for the Fernald Preserve (60 ft compared to hundreds or thousands of feet in the horizontal) before a potential discharge point for the glacial till groundwater is reached.

It can be generally interpreted from this information that if a leachate leak were able to exit through the OSDF liner system, it would be expected to migrate vertically toward the GMA (although some localized "stair step" lateral motion may also be expected to take place en route). The exact pathway that a hypothetical leachate leak from the facility would take is difficult to determine, but it is clear that an effective monitoring program needs to consider both the most likely point of entry of the leak into the subsurface environment beneath the facility (i.e., above the HTW) and the ultimate arrival of the leak at the GMA.

2.4 Existing Contamination

In the immediate vicinity of the OSDF, contaminant concentrations are present above background levels in surface and subsurface soil, the perched groundwater in the glacial till, and GMA. The nature and extent of contamination in these media were documented in the OU5 RI report (DOE 1995b). Additional characterization of the perched groundwater in the glacial till in the OSDF footprint has been documented in the OSDF Pre-Design Report (DOE 1995a). Final remediation levels (FRLs) for soil were established in the OU5 ROD (DOE 1996c), and residual contamination at concentrations below the soil FRLs interferes with the interpretation of water-quality data.

Surface and subsurface soil within the OSDF footprint was contaminated above the soil FRLs, but certification reports (DOE 1998b; 1999; 2001d; 2004b) show that contaminant concentrations are now below FRLs. As an example, the background value of uranium is 4.56 milligrams per kilogram (mg/kg) (DOE 2001c), the FRL is 82 mg/kg (DOE 1996c), and the mean values for the 17 certification units that correspond to the locations of the HTWs range from 5.96 to 57.2 mg/kg (Table 2).

Table 2. Mean Uranium Value[a] for Certification Units at or near the HTWs, Expected Groundwater Uranium Concentrations Based on the Reported Range for Uranium Leach Coefficients (K_l) in Low-Leachability Soil[b], Maximum HTW Concentration[c], and Measured Perched-water Concentration prior to OSDF Construction[d]

Certification Unit	Uranium (mg/kg)	Cell	Uranium (mg/L)			
			K_l = 185	K_l =2700	HTW-max	Pre-const
P19	38.1	1	0.206	0.014	0.012	0.020
P18	38.9	1, 2, & 3	0.210	0.014	0.029	0.010
P18-11	18.6	3	0.101	0.007	0.029	0.003
P17-33	11.7	3 & 4	0.063	0.004	0.029	0.013
P17-31	25	4	0.135	0.009	0.008	0.013
A1P2-S2SP-01	24.3	5	0.131	0.009	0.021	0.005
A1P2-S2SP-02	32.5	5	0.176	0.012	0.021	0.005
A1P2-S2SB-04	10.9	6	0.059	0.004	0.024	0.007
A1P2-S2NI-02	21.5	6	0.116	0.008	0.024	0.007
A1P2-S2SB-02	6.64	6	0.036	0.002	0.024	0.007
A1P2-S2NI-07	8.64	6 & 7	0.047	0.003	0.024	0.007
A1P2-S2SB-01	5.96	7	0.032	0.002	0.004	0.021
A1P2-S2SP-04	17.7	7	0.096	0.007	0.004	0.021
A1P2-S2NI-08	57.2	7 & 8	0.309	0.021	0.006	0.021
A1P4-C1	28.8	8	0.156	0.011	0.006	0.019
A1P4-C2	14.7	8	0.079	0.005	0.006	0.019
A1P4-C3	16.6	8	0.090	0.006	0.006	0.019

[a] Data obtained from certification reports (DOE 1998b; 1999; 2001d; 2004b).
[b] Leach coefficients obtained from Table 2.2 of the OU5 K_l study (DOE 1995c).
[c] HTW maximum concentrations taken from 2007 Site Environmental Report (DOE 2008a).
[d] Perched groundwater results taken from OSDF pre-construction study (DOE 1995a).
mg/L = milligrams per liter

DOE has been monitoring the concentration trend of refined baseline constituents in the HTWs, and some of these trends have been increasing. Given that residual contamination below the FRLs is present in the area of the HTWs, and installation of the facility changed recharge/infiltration conditions in the area, it is expected that contaminant concentrations in perched groundwater would change. The OU5 leaching coefficients for contaminated soil (DOE 1995c) can be used to calculate the range of expected groundwater uranium concentrations in below-FRL soil (Table 1), and uranium values in the HTWs (DOE 2008b) fall near or below the lower level of this range. The maximum measured concentration for perched groundwater (0.021 milligram per liter [mg/L]) prior to OSDF construction (DOE 1995b) is slightly lower than the measured maximum HTW value (Cell 3, 0.029 mg/L). However, this is expected, as the soil was disturbed during construction, and particle surfaces exposed to the atmosphere during construction may leach more readily than less-reactive surfaces in undisturbed soil. Based on the K_l value of 185 in Table 2, the uranium concentration in the Cell 3 HTW could reach a maximum value near 0.2 mg/L without uranium contribution from the OSDF.

Pre-OSDF GMA contamination near the OSDF footprint was present in the Plant 6 area, which is approximately 300 ft west of the OSDF. During the RI, a uranium plume was detected in this area. Direct-push sampling conducted in 2000 and 2001, in support of the *Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas* (DOE 2001e), indicated that the uranium plume in the Plant 6 area was no longer present. It is believed that the uranium plume dissipated to concentrations below the FRL as a result of the shutdown of plant operations in the late 1980s and the pumping of highly contaminated perched water as part of the Perched Water Removal Action #1 in the early 1990s. Because a total uranium plume with concentrations above the groundwater FRL was no longer present in the Plant 6 area at the time of the design, a restoration module for the Plant 6 area became unnecessary and was no longer planned.

Deep excavation work in the Plant 6 area was completed in 2004. As a follow-up to the excavation work, direct-push groundwater sampling was conducted in 2004 in the area to determine if any post-excavation groundwater FRL exceedances for uranium or technetium-99 were present in the GMA. The results of the direct-push groundwater sampling showed no uranium or technetium-99 FRL exceedances.

Since the decision not to install extraction wells in the Plant 6 Area was approved in 2001, uranium FRL exceedances have been measured at one well in the area, monitoring well 2389. The uranium FRL exceedances at well 2389 will continue to be monitored as part of the IEMP. Although a thin layer of contamination appears to be present in the upper 1 ft or so of the aquifer at monitoring well 2389, the contaminant mass is not sufficient to warrant installation of a groundwater recovery well. It is expected that the concentration of uranium at well 2389 will dissipate over time. The data will continue to be tracked as part of the IEMP sampling activities.

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3.0 Regulatory Analysis and Strategy

The OSDF groundwater/leak detection and leachate monitoring plan is designed to comply with all regulatory requirements associated with groundwater detection monitoring and leachate monitoring for disposal facilities. The sources of these regulatory requirements are the ARARs listed in the RODs for OU2, OU3, and OU5. This section summarizes the regulatory requirements by describing each ARAR and presents the regulatory strategy for compliance with the ARARs.

As indicated in Section 1.1, there is institutional knowledge regarding the various complexities associated with the regulatory strategy for the OSDF leak detection and data evaluation processes. This information should be considered during future post-closure evaluations.

3.1 Regulatory Analysis Process and Results

The analysis of the regulatory drivers for groundwater monitoring for the OSDF was conducted by examining the suite of ARARs in the Fernald Preserve's approved OU RODs to identify a subset of specific groundwater monitoring requirements for the OSDF. Three RODs (OU2, OU3, and OU5) include requirements related to onsite disposal. The RODs for these three OUs were reviewed, and the ARARs relevant to the OSDF were identified. The results of this review are provided in Appendix A and are summarized below.

The following regulations were identified as being ARARs for the OSDF groundwater monitoring program:

- Ohio Solid Waste Disposal Facility Groundwater Monitoring Rules, *Ohio Administrative Code* (OAC) 3745-27-10, which specify groundwater monitoring program requirements for sanitary landfills (although the OSDF is not a sanitary landfill). These regulations describe a three-tiered program for detection, assessment, and corrective measures monitoring.
- Resource Conservation and Recovery Act (RCRA)/Ohio Hazardous Waste Groundwater Monitoring Requirements for Regulated Units, 40 CFR 264.90–99 (OAC 3745-54-90–99), which specify groundwater monitoring program requirements for surface impoundments, landfills, and land treatment units that manage hazardous wastes. Similar to the Ohio Solid Waste regulations, these regulations describe a three-tiered program of detection, compliance, and corrective action monitoring. Because the Ohio regulations mirror or are more stringent than the federal regulations, the Ohio regulations are the controlling requirements and are cited in this document.
- Uranium Mill Tailings Radiation Control Act (UMTRCA) regulations codified at 40 CFR 192 Subpart D, which specify standards for uranium byproduct materials in piles or impoundments. This regulation requires conformance with the RCRA groundwater monitoring performance standard in 40 CFR 264.92. Compliance with RCRA/Ohio Hazardous Waste regulations for groundwater monitoring will fulfill the substantive requirements for groundwater monitoring in the UMTRCA regulations.
- DOE M 435.1-1, *Radioactive Waste Management Manual*, which requires low-level radioactive waste disposal facilities to perform environmental monitoring for all media, including groundwater. Complying with RCRA/Ohio Hazardous Waste and Ohio Solid Waste regulations for groundwater monitoring along with incorporating pertinent

radiological parameters will fulfill the requirement for groundwater monitoring in this directive.

The following drivers necessitated an overall leak detection strategy:

- Ohio Municipal Solid Waste Rules, OAC 3745-27-06(C)(9a) and OAC 3745-27-10, which require that facilities prepare a groundwater monitoring plan that incorporates leachate monitoring and management to ensure compliance with OAC 3745-27-19(M)(4) and OAC 3745-27-19(M)(5).
- Ohio Municipal Solid Waste Rules—Operational Criteria for a Sanitary Landfill Facility, OAC 3745-27-19(M)(4) and (5), which require submittal of an annual operational report including:
  - A summary of the quantity of leachate collected for treatment and disposal on a monthly basis during the year, location of leachate treatment and/or disposal, and verification that the leachate management system is operating in accordance with the rule.
  - Results of analytical testing of an annual grab sample of leachate from the leachate management system.

3.2 OSDF Monitoring Regulatory Compliance Strategy

Of the ARARs presented above, the Ohio Solid Waste and the Ohio Hazardous Waste regulations are the most prescriptive and, therefore, warrant further discussion on how compliance with these two regulatory requirements will be met. The leak detection monitoring requirements of these two sets of regulations are similar, and they dictate the development of detection monitoring plans capable of determining the facility's impact on the quality of water in the uppermost aquifer and any significant zones of saturation above the uppermost aquifer underlying the landfill.

Typically a detection monitoring program consists of the installation of upgradient and downgradient monitoring wells, routine sampling of the wells, and analysis for a prescribed list of parameters, followed by a comparison of water quality upgradient of the landfill to water quality downgradient of the landfill. The detection of a statistically significant difference in downgradient water quality suggests that a release from the landfill may have occurred.

As discussed in Section 2.0, low permeability in the glacial till and preexisting contamination within the glacial till and the GMA add complexity to the development of a groundwater detection monitoring program consistent with the standard approach of the Solid and Hazardous Waste regulations. Both sets of regulations accommodate such complexities by allowing alternate monitoring programs, which provide flexibility with respect to well placement, statistical evaluation of water quality, facility-specific analyte lists, and sampling frequency. The OSDF groundwater/leak detection monitoring program has required the use of an alternate monitoring program, in accordance with the criteria in the Ohio Solid and Hazardous Waste regulations. Compliance with the criteria is discussed below in Section 3.2.1.

The regulatory requirements for the leachate monitoring program are provided by the Ohio Solid Waste regulations. The compliance strategy for the leachate monitoring program is discussed below in Section 3.2.2.

3.2.1 Leak Detection Monitoring Compliance Strategy

The leak detection monitoring program for the OSDF includes routine sampling and analysis of water drawn from four zones within and beneath the disposal facility: the LCS, the LDS (within the facility), perched water in the glacial till (beneath the facility), and the GMA (beneath the facility). This monitoring approach takes the unique hydrogeologic and preexisting contaminant situation at the site into consideration. However, this approach differs from a typical leak detection monitoring program in several ways and requires a compliance strategy to ensure that the program meets or exceeds the substantive requirements of the Ohio Solid and Hazardous Waste regulations. Below is a detailed discussion of compliance with several elements of the program, including alternate well placement, statistical analysis, monitoring frequency, and parameter selection. The implementation of the OSDF groundwater/leak detection program is presented in Section 4.0 and Appendix B.

3.2.1.1 Alternate Well Placement

The Ohio Solid Waste regulations require that a groundwater monitoring system consist of a sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from both the uppermost aquifer and any overlying significant zones of saturation (OAC 3745-27-10[B][1]). Groundwater samples are obtained through wells installed in the glacial till and the GMA.

The regulations also state that the wells must represent the quality of groundwater passing directly downgradient of the limits of solid waste placement (OAC 3745-27-10[B][1][b]). In lieu of installing vertical glacial till monitoring wells along the perimeter of the OSDF, horizontal wells were installed beneath the OSDF and screened beneath the liner-penetration box of the LDS for each disposal cell where the greatest potential for leakage exists. Horizontal wells are preferred to vertical wells due to restrictions on well installation within 200 ft of waste placement so as to avoid interference with the disposal facility cap, and the absence of significant lateral flow within the till. As discussed in Section 2.0, the time required for contaminants to migrate laterally in the till toward wells located 200 ft from the limits of waste placement greatly exceeds the vertical travel time through the glacial till; therefore, the aquifer would be impacted by contaminants long before vertical wells in the glacial overburden located outside the restricted area could detect the release. Although the existence of the OSDF may result in dewatering of the glacial till such that samples cannot be regularly obtained, horizontal wells installed beneath the liner of the OSDF represent the highest potential for detecting releases to the till. Such an alternate placement for the till wells is allowed in the Ohio Solid Waste regulations.

The performance criteria in OAC 3745-27-10(B)(4) require that the number, spacing, and depth of the wells must be based on site-specific hydrogeologic information and must be capable of detecting a release from the facility to the groundwater at the closest practical location to the limits of solid-waste placement. The placement of till wells beneath the facility, as opposed to along its perimeter, meets or exceeds the requirement to be located adjacent to waste placement.

3.2.1.2 Alternate Statistical Analysis

A statistical analysis is required in both the Ohio Solid and Hazardous Waste regulations (OAC 3745-27-10[C][6] and OAC 3745-54-97[H]). The statistical analysis methods listed in the regulations are parametric analysis of variance (ANOVA), an ANOVA based on ranks, a tolerance or prediction interval procedure, a control chart approach, or another statistical test method. The control chart approach (combined Shewart CUSUM [cumulative sum] control charts) is being used, as it has been determined the most viable approach; however, problems with control charts exist. The method of evaluation for the OSDF groundwater/leak detection monitoring data is an intra-well trend analysis prior to the establishment of background (baseline) conditions in the perched water and GMA beneath the OSDF. Statistically significant evidence of an upward trend in some constituents negates the use of control charts for those constituents. Control charts are produced for those constituents in the HTW and GMA wells that are stable. Concentrations of the unstable constituents in the HTW and GMA wells are being monitored and trended over time. As constituent trends become stable, control charts will be prepared.

Although vertical monitoring wells are installed in the GMA upgradient and downgradient of the OSDF, an intra-well comparison is more appropriate than an upgradient versus downgradient comparison until aquifer restoration is complete. The direction of groundwater flow beneath the OSDF is being temporarily influenced by the pump-and-treat remedy. Five years of water level measurements prior to operating the pump-and-treat system (1988 through 1993) indicate that groundwater flowed from the west to the east beneath the OSDF (refer to OU5 RI report, Figure 3-50). The pump-and-treat system that is currently operating pulls groundwater in the area of the OSDF to the southwest. It will not be possible to establish a long term upgradient-downgradient monitoring relationship beneath the OSDF until the pump-and-treat remedy ends. The current early estimate for the completion of the remedy is 2035. Transient flow conditions within the aquifer, as well as the existence and expected fluctuation of contaminant concentrations at levels below the FRLs, discourage the use of a statistical comparison of upgradient and downgradient water quality as a reliable indicator of a release from the OSDF.

To date, establishing baseline conditions with statistical analyses has proven to be difficult due to a lack of steady state conditions. Steady-state conditions, which are a requirement of control charting, have not been reached for all constituents.

Recognizing that lack of steady state concentration conditions complicate the data evaluation process in the perched system and GMA, DOE conducted a common-ion study. The study was a comprehensive geochemical and statistical evaluation of the concentrations of 50 aqueous ions in fluid samples from the LCS, LDS, and HTWs of each cell (DOE 2008b). The study concluded that:

- Only a limited number of ions can serve as indicator ions because few ions have concentrations in the source horizon that exceeded their concentration in the target horizon by at least a factor of four.
- Many of the indicator ions in the target horizons show concentration trends or serial correlation, which precludes the use of control charts because steady-state conditions have not been established in the fluid-solid system.

- Fluid volume is the key monitoring parameter to indicate the potential for leachate migration, and the sampling of and analysis for indicator ions are useful only if the hydraulic conditions permit leachate to migrate.

3.2.1.3 Alternate Parameter Lists

The process used to define an alternate parameter list, described in detail in Appendix E, used the extensive RI database and fate and transport modeling to evaluate potential indicator parameters. RIs have been completed for all Fernald Preserve source terms and contaminated environmental media. The RIs included extensive sampling and analysis to characterize wastes and quantify environmental contamination so that health protective remedies, such as the construction of the OSDF, could be selected.

Extensive databases were also used to develop WAC, which consist of concentration and mass-based limitations on the waste entering the OSDF. The WACs for the OSDF were developed with consideration of the types, quantities, and concentration of wastes that would be placed into the OSDF; the leachability, mobility, persistence, and stability of the waste constituents in the environment; and the toxicity of the waste constituents. Of 93 constituents that were evaluated for waste acceptance, 18 were identified as having a relatively higher potential to impact the aquifer within the 1,000-year specified performance period. Maximum allowable concentration limits were established for wastes containing these constituents. These 18 constituents were chosen as the initial site-specific leak detection monitoring parameters (initial baseline constituents).

The factors used to establish WAC for the OSDF are similar to the consideration criteria for developing an alternate parameter list specified in the Ohio Solid and Hazardous Waste regulations (OAC 3745-27-10[D][2] and [3]; OAC 3745-54-93[B]; OAC 3745-54-98[A]); and Ohio EPA policy and guidance (Ohio EPA 1995, 1996, 1997) for a hazardous waste landfill. The process is to identify waste constituents that are expected to be derived from wastes placed in the OSDF. The methodology for developing an OSDF-specific leak detection monitoring parameter list used the WAC methodology and the Ohio Solid and Hazardous Waste regulatory criteria to identify waste constituents that are expected to be derived from wastes placed in the OSDF. This effort was not completely successful, as waste materials are nearly identical in composition to material outside of the OSDF.

Additionally, review of OSDF monitoring data for the 18 constituents that were chosen for the initial site-specific leak detection monitoring parameters indicated that the majority of the constituents were not detected. As a result, DOE, Ohio EPA, and EPA agreed that the list of constituents monitored could be refined to those that were detected more than 25 percent of the time.

Twelve rounds of sampling for the initial site-specific leak detection monitoring parameters were completed at all eight cells in 2007. At the completion of the 12 rounds of sampling, five constituents/parameters were identified as having been detected at least 25 percent of the time. These five constituents/parameters (boron, sulfate, uranium, total organic compounds, and total organic halogens) make up the refined baseline for each cell.

In 2002 there were relatively high concentrations of sulfate in the Cells 4 and 5 LCS water prior to waste placement, indicating a sulfate source (possibly gypsum) in the gravel composing the LCS layer. Due to sulfate's high mobility and the presence of an ongoing source in the LDS/LCS layers, it was added to the leak detection sampling program in 2003. This is discussed further in Appendix E.

In summary, baseline monitoring has progressed in two steps:

- Initial baseline monitoring—based on 12 rounds of samples for the 18 initial site-specific leak detection monitoring parameters.
- Refined baseline monitoring—based on initial baseline parameters that are detected 25 percent or more of the time.

Establishing baseline water chemistry in the perched groundwater and GMA horizon under each cell is complicated by the construction process used to install the HTWs and the existence of past groundwater contamination in the till and GMA zones. The installation of the HTWs involved excavation of a trench, placement of a porous filter media composed of sand, and then backfill with the porous media and till material. During this installation, the subsurface chemical properties of the till were altered by the contact of the excavated till material with the atmosphere (oxygen-rich environment). Contact of the subsurface till with the atmosphere may have impacted (1) the oxidation state of metals on the surface of grains and in the pore water and (2) microbial species that mediate oxidation-reduction reactions in the subsurface. Additionally, historical contamination in perched groundwater and GMA horizons surrounding the cell may be migrating and diffusing into the HTW and GMA monitoring wells.

As discussed in the preceding section, to address some of these uncertainties, DOE conducted a common-ion study. Results of the study were presented in *Evaluation of Aqueous Ions in the Monitoring Systems of the On-Site Disposal Facility* (DOE 2008b). The report identified four additional constituents—iron, manganese, sodium, and lithium—that are potentially beneficial leak detection monitoring parameters for the OSDF. Beginning in 2009 these four additional constituents were monitored quarterly in all horizons (LCS, LDS, HTW, and the GMA). The common-ion report also identified a few constituents in the HTW that passed the statistical screening requirements for control charting.

In addition to sampling for the approved initial baseline constituents, refined baseline constituents, and the selected common-ion constituents, DOE continued to sample the LCS once a year for the full list of Appendix I (OAC 3745-27-10) and polychlorinated biphenyl (PCB) constituents. A statistical screening process was developed to evaluate the results of the continued sampling with the objective of determining if any constituent not already on the alternate parameter list might also be a useful monitoring constituent. The screening process was initially presented in the *Fernald Preserve 2007 Site Environmental Report* (DOE 2008a), and was conducted once a data set of eight samples was available for a cell. The screening process has been conducted for all eight Cells, and the results have been reported as follows:

- Cells 1, 2, and 3 reported in the Fernald Preserve 2007 Site Environmental Report (DOE 2008a).
- Cells 4 and 5 reported in the Fernald Preserve 2009 Site Environmental Report (DOE 2010).

- Cell 6 reported in the Fernald Preserve 2010 Site Environmental Report (DOE 2011).
- Cells 7 and 8 reported in the Fernald Preserve 2011 Site Environmental Report (DOE 2012).

Because all eight cells have gone through the parameter selection statistical process, annual sampling in the LCS continues for an agreed to modified Appendix I parameter list found in Table 1 of Appendix B.

The assessment process was based on showing statistically that the average LCS concentration was greater than either the pre-design or background average concentration. A constituent with a greater average LCS concentration than either pre-design or background was added to the monitoring list for deeper horizons. The monitoring list contains 24 parameters to be sampled for in all horizons, except the HTW.

Monitoring List

Parameter	Source for Selection
Uranium	Refined Baseline
Boron	Refined Baseline
TOC	Refined Baseline
TOX	Refined Baseline
Sulfate	Refined Baseline
Iron	Common Ion Report[a]
Lithium	Common Ion Report
Manganese	Common Ion Report
Sodium	Common Ion Report
Arsenic	Screened in 2007
Cobalt	Screened in 2007
Nickel	Screened in 2007
Selenium	Screened in 2007
TDS	Screened in 2007
Zinc	Screened in 2007
Alkalinity	Screened in 2009
Barium	Screened in 2009
Calcium	Screened in 2009
Chloride	Screened in 2009
Copper	Screened in 2009
Magnesium	Screened in 2009
Nitrate/nitrite	Screened in 2009
Potassium	Screened in 2009
Chromium	Screened in 2011

Note: Technetium-99 is also sampled in Cell 8 only.
[a] *Evaluation of Aqueous Ions in the Monitoring Systems of the On-Site Disposal Facility* (DOE 2008b)

Ohio EPA proposed reducing the list of parameters being sampled in the HTW to just uranium, arsenic, and tritium (beginning in the second quarter of 2011). Sampling for tritium in all horizons was agreed to for a year. Tritium was added to the list of constituents because it was hoped that it might serve as a useful monitoring parameter. Tritium was used in exit signs, which may be in the OSDF with other building materials. Tritium has a relatively short half-life (approximately 12 years) but is fairly mobile and if present could be a good potential leak indicator parameter. One year of tritium sampling results though showed that tritium was not a good monitoring parameter for the OSDF. Therefore, tritium is no longer sampled for in any of the monitoring horizons. In addition to sampling the HTWs for uranium and arsenic, DOE also samples for sodium and sulfate in order to prepare bivariate plots. Bivariate plots are useful in illustrating that the chemical signatures of the different monitoring horizons (LCS, LDS, HTW) are separate and distinct.

Sampling lists are provided in Appendix B, in Tables 1 through 3 as follows:

- Table 1: Annual LCS Monitoring List Requirements for Cells 1 through 8
- Table 2: Semiannual LCS, LDS, and GMA Monitoring List Requirements for Cells 1 through 8
- Table 3: Semiannual HTW Monitoring List Requirements for Cells 1 through 8

3.2.1.4 Alternate Sampling Frequency

The Ohio Solid Waste regulations require that, for detection monitoring, at least four independent samples from each well will be taken during the first 180 days after implementation of the groundwater detection monitoring program and at least 8 independent samples in the first year to determine the background (i.e., baseline) water quality (OAC 3745-27-10[D][5][a][ii][a]). The requirement to collect eight independent samples is only applicable to wells installed after August 15, 2003, the date that the code became effective. The Ohio Hazardous Waste regulations do not specify a frequency for determining a background data set. The Ohio Hazardous Waste regulations do require a performance standard for establishing background; OAC 3745-54-97(G) states that the number and kinds of samples taken to establish background be appropriate for the statistical test employed.

Experience and technical knowledge gained from cell monitoring indicated that it was necessary to collect initial baseline samples quarterly. Sampling frequencies were based on the following: HTWs and GMA wells were sampled bimonthly after waste placement until 12 samples were collected for statistical evaluation. These frequencies were selected to develop an appropriate statistical procedure, to address OSDF construction schedules, and to compensate for the varying temporal conditions and seasonal fluctuations. After sufficient samples were collected for statistical analysis, samples were collected quarterly from the HTWs and GMA. The Ohio Solid Waste regulations allow for a semiannual sampling frequency for detection monitoring after the first year but also allow for the proposal of an alternate sampling program (OAC 3745-27-10[D][5][a][ii][b] and [b][ii][b], and 3745-27-10[D][6]). The frequency of sampling was reduced from a quarterly frequency to a semiannual frequency beginning in January 2014.

3.2.2 Leachate Monitoring Compliance Strategy

The Solid Waste regulations (OAC 3745-27-19[M][5]) require collection and analysis of leachate annually for Appendix I constituents and PCBs listed in OAC 3745-27-10. Ohio Solid Waste regulations OAC 3745-27-10(D)(2) and (3) allow for the selection of an alternate list of constituents to monitor in lieu of some or all of the constituents listed in Appendix I of OAC 2745-27-10. As described in Section 3.2.1.3 and Appendix E, an alternate parameter list has been approved for the OSDF.

Although not specified in the OU RODs as an ARAR, the federal RCRA (Hazardous Waste) regulations include specific requirements in 40 CFR 264.303 for monitoring the volume of liquid collected from a disposal facility's LDS. Regulation 40 CFR 264.302 includes provisions for determining an action leakage rate that, if exceeded, would prompt specific response and notification actions. An action leakage rate of 200 gpad and an initial response leakage rate of 20 gpad were established during the design of the OSDF. The response and notification process for an exceedance of both the initial response leakage rate and the action leakage rate (40 CFR 264.304) is provided in Section 6.0.

The leachate monitoring strategy, as part of the groundwater monitoring plan and required by OAC 3745-27-06(C)(7), must include provisions for obtaining the monthly volume of leachate collected for subsequent treatment, provide the method of leachate treatment and/or disposal, and include verification that the leachate management system is operating properly (OAC 3745-27-19[M][4]). Monitoring to verify that the leachate management system is operating properly is identified in the *Wastewater Treatment Outside Systems Procedure for the Fernald Preserve, Fernald, Ohio* (DOE 2014b) and the *Converted Advanced Wastewater Treatment Facility Procedure for the Fernald Preserve, Fernald, Ohio* (DOE 2014a) and in Appendix D of this document.

The monthly volume of leachate collected for treatment and subsequent disposal will be obtained based on the program in 40 CFR 264.303(c) to determine the flow rates of leachate collected in the LCS and water in the LDS. Monitoring the flow rates will provide data for determining the volume of leachate collected and will also provide data pertinent to the leak detection monitoring program. The flow rates are part of the leak detection monitoring program and are discussed further in Section 4.0. A separate leachate management monitoring strategy is provided as Section 5.0 to provide information on the method of leachate treatment and disposal, including analysis of parameters useful for leachate treatment.

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4.0 Leak Detection Monitoring Program

This section presents the technical approach for leak detection monitoring at the OSDF, in light of the regulatory requirements for leak detection monitoring summarized in Section 3.0. This section includes a summary of the objectives of the program, a description of the major program elements, the selection process for analytical parameters (i.e., site-specific leak detection indicator parameters), and the strategy for evaluating the data to determine whether a leak has occurred. The subsections are as follows:

- Section 4.1: Introduction.
- Section 4.2: Monitoring Objectives.
- Section 4.3: Leak Detection Monitoring Program Elements.
- Section 4.4: Sample Collection.
- Section 4.5: Leak Detection Data Evaluation Process.

Additionally, Appendixes B and C provide the Project-Specific Plan and Data Quality Objectives for the OSDF Monitoring Program for each cell, with details on specific monitoring lists and frequencies. Appendix E describes the selection process for site-specific leak detection indicator parameters. Section 5.0 describes leachate management activities. Section 6.0 provides a summary of the notifications and potential follow-up response actions that accompany the monitoring program.

4.1 Introduction

As discussed in Section 1.0, the OSDF leak detection monitoring program constitutes the first tier of a three-tiered detection, assessment, and corrective action monitoring strategy that is required for engineered disposal facilities. Consistent with this three-tiered approach, follow-up assessment and corrective action monitoring plans will be developed and implemented as necessary if it is deemed appropriate. Conversely, if the detection monitoring successfully demonstrates that leachate leaks have not occurred, then the monitoring program will remain in the first-tier "detection mode" indefinitely. The follow-up assessment and/or corrective action monitoring plans, if found to be necessary, would be prepared as new, independent plans that would supersede this first-tier detection program.

In leak detection assessments, water quality data will be evaluated in context with preexisting contamination data and LDS flow data. The leak detection monitoring program monitors two horizons inside of each cell: the LCS and the LDS. A perched groundwater monitoring well is located and monitored beneath the secondary facility liner and 3-ft-thick compacted clay layer, directly below the LDS and LCS liner-penetration boxes of each cell (Figure 3). A GMA groundwater monitoring well is situated on the east and west of each cell at depths ranging from 40 to 90 ft beneath the OSDF. The data collected from the four components are evaluated comparatively over time.

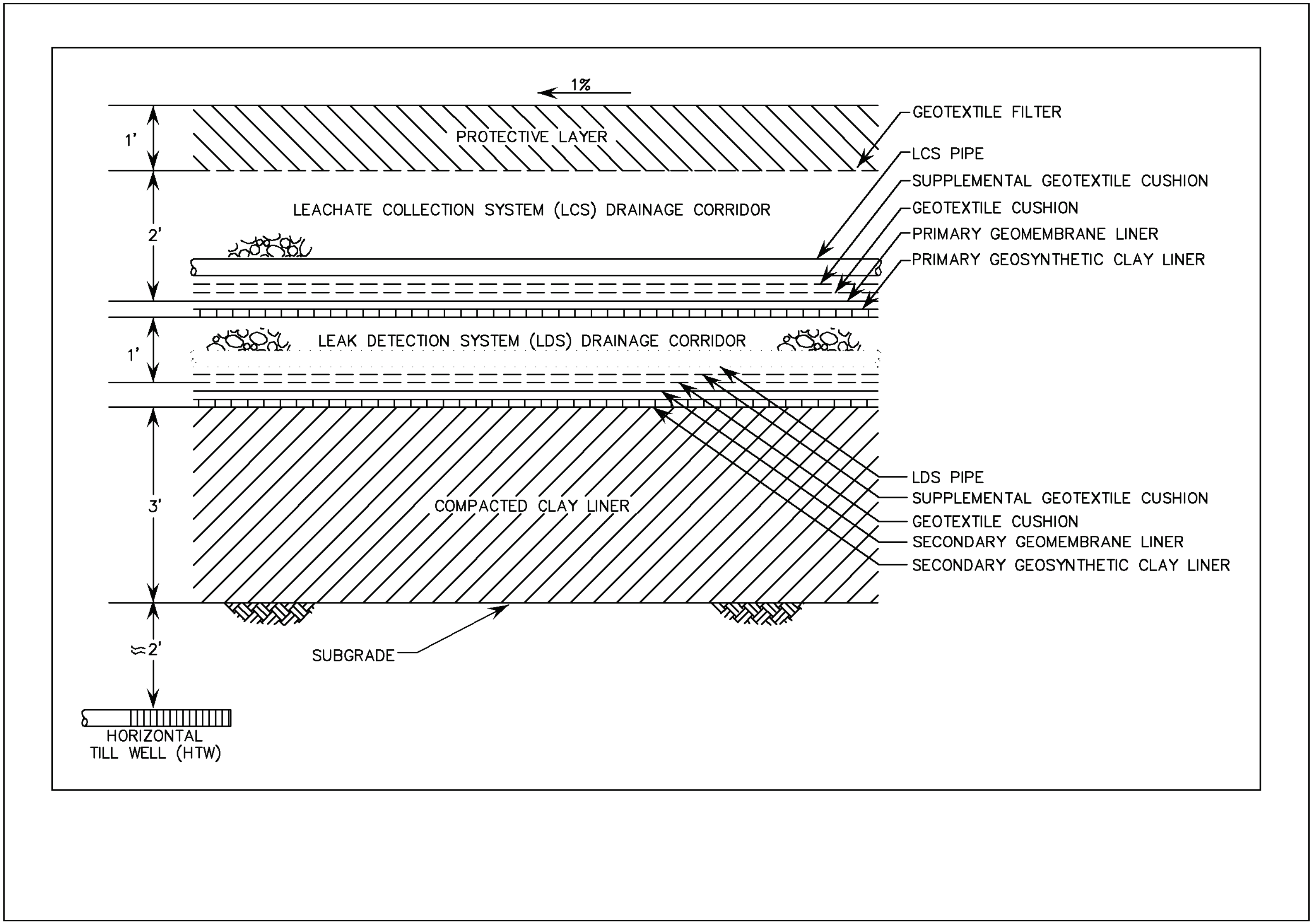

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Figure 3. OSDF Liner System with HTW at the Drainage Corridor

The GMA is the prime resource of concern that could potentially be affected by the OSDF in the unlikely event that a leachate leak occurred. Therefore, the aquifer is monitored for water quality at the immediate boundary of the OSDF. However, as discussed in Section 2.0, contaminant travel times to the aquifer through the glacial till beneath the OSDF are of such length that reliance on GMA monitoring alone would be insufficient to provide effective early warning of a leak from the facility. Therefore, perched groundwater monitoring wells are installed directly below the liner-penetration box of each cell.

Additionally, as indicated in Sections 1.1 and 3.0, there is institutional knowledge regarding the various complexities associated with the regulatory strategy for the OSDF leak detection and data evaluation processes. This information has been considered in the monitoring strategy.

4.2 Monitoring Objectives

The fundamental objective of the leak detection monitoring program is to provide the leachate flow and water quality data needed to determine if a leak may be occurring from the OSDF. Recognition of this fundamental objective allows the Fernald Preserve to move confidently into the next regulatory-based tiers of the program—assessment and corrective action monitoring—if required. This fundamental objective is the primary driver for all of the key site-specific elements (i.e., monitoring locations, frequencies, analytical parameters, and follow-up response actions) of the program.

In addition to this fundamental objective, several other objectives have been considered in the site-specific design of the leak detection program:

- The program should have the ability to distinguish an OSDF leak from the above-background preexisting levels of contamination that are found in the subsurface.
- All monitoring wells must be installed at locations and with construction methods that do not interfere with or compromise the integrity of the cap and liner system of the OSDF.
- The program needs to satisfy the site-specific regulatory requirements for leak detection monitoring summarized in Section 3.0.

The leak detection monitoring approach described below meets the intent of providing early detection of a release from the OSDF within the hydrogeologic regime at the Fernald Preserve, and is tailored to accommodate the additional program design objectives summarized above.

4.3 Leak Detection Monitoring Program Elements

4.3.1 Overview

The leak detection monitoring program involves (1) tracking the quantity of liquid produced within the LCS and LDS over time to determine if enough hydraulic head is present in the facility to drive leachate through a liner breach, and (2) water quality monitoring of the leachate, the perched groundwater, and groundwater in the GMA. The success of the leak detection monitoring strategy for the OSDF is dependent upon understanding how a leak might occur from the facility, and understanding that preexisting contaminant concentrations in the perched groundwater and GMA complicate water quality data interpretations.

The approved design for the OSDF is presented in detail in the initial OSDF Design Package and subsequent approved follow-up design and construction drawing packages. The OSDF is a double-lined landfill consisting of eight individual cells that were constructed in phases. As shown in Figure 3, the liner for each cell is a composite liner system, assembled from the following layers (top to bottom): a soil cushion layer, geotextile fabric, LCS drainage layer, primary composite liner, high-density polyethylene (HDPE) (geotextile fabric, HDPE geomembrane, and geosynthetic clay liner), LDS drainage layer, and the underlying secondary composite liner (HDPE geomembrane, geosynthetic clay liner, and 3 ft of compacted clay). Both the LCS and LDS drainage corridors drain to the west within each cell. The base of each cell liner is sloped toward the center line of the cell, and the center line of the base is sloped toward the west. At the western edge of each cell liner, any liquid within the LCS and LDS is collected in pipes that pass through the liner-penetration box and flow to the respective cell's valve house. As identified previously, the liner-penetration box represents the area with the greatest leak potential for each cell and is considered the primary location where a leak would first enter the environment if a leak were to occur.

Each cell is also constructed with an engineered composite cover. The cover system consists of the following layers (top to bottom): a vegetation cover layer, a topsoil layer, a granular filter layer, a bio-intrusion barrier, a geotextile filter, a cover drainage layer, the primary composite cap (geotextile cushion, HDPE geomembrane, geosynthetic clay liner, and compacted clay), and an underlying contouring layer. The cover system was completed in 2006. Now that the cover system is in place and the cell contents are expected to reach equilibrium, leachate production is expected to diminish as a result of the moisture infiltration barrier properties of the cover system. During the time that the cell contents move toward equilibrium, leachate accumulation in the LCS drainage layer is expected to diminish over time.

A construction quality assurance/quality control program was executed for each cell of the OSDF. The synthetic liners and caps of each cell were inspected and tested for defects at the time of installation. Given the attention to quality assurance/quality control during installation of the OSDF liner system, it is doubtful that a breach in the liner would have gone unnoticed, but it is possible that a breach could develop. Such a breach would provide a potential pathway for leachate migration, but adequate hydraulic head is needed to drive leachate through the breach and from the facility.

The performance of each cell is monitored individually; each cell has its own engineered LCS and LDS drainage layers, perched groundwater monitoring component, and upgradient and downgradient GMA monitoring wells.

As described earlier, a secondary liner is present at the base of each cell beneath the LDS. In order for leachate to migrate from the OSDF, a defect or tear (breach) would need to exist in the secondary liner and enough hydraulic head would be needed to drive the leachate through the breach. Without adequate hydraulic head to drive leachate through a liner breach, leachate would follow the pathway of least resistance, which would be across the top of the liner through gravel in the LDS drainage corridor. The gravel has a much higher hydraulic conductivity relative to the underlying compacted clay in the liner, or the gray clay that is present beneath the facility.

For a leak to occur and be detected in an HTW (the first monitoring point beneath the facility), a liner breach needs to exist, and enough hydraulic head needs to be present in the facility to drive leachate through the breach. The action leakage rate is the monitoring criterion used to assess the presence of hydraulic head in the cell of the facility. The action leakage rate is the maximum design flow rate that the LDS can remove without the fluid head on the bottom liner of the facility exceeding 1 ft (40 CFR 264.302). Stated in another way, it is the flow rate that corresponds to a hydraulic head within the facility capable of driving fluid through a liner breach, if the breach occurs at the penetration box. The OSDF has an action leakage rate of 200 gpad (DOE 1997).

Flow is monitored in the LDS of each cell and reported annually in the Site Environmental Report. To be conservative, DOE uses an initial response leakage rate of 1/10 of the action leakage rate (i.e., 20 gpad). Should the initial response leakage rate of 20 gpad ever be measured, DOE will begin the process of determining why the flow is increasing so that actions can be taken long before the actual action leakage rate is ever reached.

4.3.2 Monitoring the Engineered Layers within the OSDF

Water quality samples were collected from individual LCS and LDS drainage layers within each cell during waste placement and after cell closure as described below and in Section 5.0. In addition to water quality monitoring, the quantity of leachate and fluid flowing through the LCS and LDS layers is recorded and reported.

4.3.2.1 Leachate Collection System

The LCS drainage layer collects infiltrating water and keeps it from entering the environment. Since each cell was capped, the volume of leachate draining through the LCS of each cell has decreased. At some time in the future, decreased flow may limit the available sample volume and subsequently the number of parameters that can be analyzed.

The LCS drains to the west through an exit point in the liner to the leachate transmission system on the west side of the OSDF. From there, the leachate collected is periodically pumped to the CAWWT backwash basin or directly to CAWWT feed tanks. Both flow (quantity/volume) and water quality information are collected from the LCS drainage layer according to Section 4.4 and Appendix B.

4.3.2.2 Leak Detection System

By design, the primary composite liner located underneath the LCS drainage layer should not leak. By design, leachate that accumulates in the LCS drainage layer above the primary liner is drained by gravity out of the cells to further reduce the potential for leakage by minimizing the level of fluid buildup in the primary liner. Notwithstanding this design, a second fluid collection layer, the LDS drainage layer, is positioned beneath the primary composite liner to provide a means to track the integrity and performance of the primary liner. If fluids collect within the LDS layer, by design the fluids gravity-drain to the west, out of the cells, where they are routed for treatment.

Similar to the LCS, fluid volumes in the LDS have decreased since the cells were capped. Decreased flow may limit the available sample volume and possibly affect the number of parameters that can be analyzed. Below the LDS drainage layer is a secondary composite liner that comprises an HDPE geomembrane, geosynthetic clay liner, and a 3-ft-thick layer of compacted clay. This secondary liner serves as the lowermost hydraulic barrier in the liner system and inhibits fluids from entering the environment before they are collected and removed through the LDS drainage corridor.

Like the LCS drainage corridor, both flow (quantity/volume) and water quality information are collected from the LDS drainage layer according to Section 4.4 and Appendix B.

4.3.3 Monitoring Perched Groundwater Beneath the Facility

The perched groundwater monitoring component of the program is designed to monitor for the presence of leachate leakage from the OSDF at its first point of entry into the Fernald Preserve's natural hydrogeologic environment. As discussed in Section 1.0, a horizontally oriented glacial till monitoring well (i.e., HTW), positioned directly beneath the location of the LCS and LDS liner-penetration box in each cell, represents the most feasible site-specific approach to monitor for first entry leakage from the OSDF into the Fernald Preserve's environment.

The HTWs were installed as part of the subgrade construction activities for each cell of the OSDF. They were installed prior to waste placement, therefore eliminating final positioning uncertainties that would be associated with post-construction horizontal drilling techniques. The vertical portion of each of the monitoring wells is located along the western side of the OSDF, while the sample collection interval is positioned beneath the bottom of the secondary composite liner in alignment with the location of the LCS and LDS liner-penetration box.

Lithologic and hydraulic characterization of the till in the vicinity of the OSDF indicates that the clay-rich deposits of carbonate and silicate grains may not readily yield fluid to a well. The amount of saturation in the till is further reduced by the barrier properties of the composite cover and liner system of the OSDF, which operate to significantly reduce local infiltration beneath the facility. These conditions may make it difficult or impossible to obtain sufficient sample volume from the till wells to perform detailed water quality analyses. If sufficient sample volume cannot be obtained to perform the full list of required analyses, analyses will be prioritized as warranted.

Water quality information is collected from the HTWs according to Section 4.4 and Appendix B.

4.3.4 Monitoring the GMA

The subsections below describe the GMA component of the program, including a discussion of the influence of aquifer restoration activities on the program, the siting of the monitoring wells, and the use of the groundwater models (i.e., Variably Saturated Analysis Model in 3 Dimensions [VAM3D] and Sandia Waste Isolation Flow and Transport [SWIFT]) to evaluate the adequacy of the planned well locations.

4.3.4.1 Siting of the GMA Monitoring Wells

The GMA monitoring wells are located immediately adjacent to the OSDF, just outside the footprint of the final composite cap configuration, so as not to interfere with the integrity of the facility. Each cell has its own set of monitoring wells to assist with the evaluation of conditions associated with that cell. As each new cell was brought on line, its associated monitoring wells were installed before (or concurrently with) the construction of the cell liners so that the wells were available for the initiation of baseline sampling prior to waste placement. Thus, well installations have followed the north-to-south progression of OSDF cell construction. The OSDF is bordered by a network of 18 GMA monitoring wells that provide upgradient and downgradient monitoring points for each cell (Figure 4). All monitoring wells were constructed in accordance with the *Sitewide CERCLA Quality Assurance Project Plan* (DOE 2003) for Type 2 GMA wells.

The overall objective of the GMA component of the leak detection monitoring program is to provide long-term surveillance. Therefore, the current and future (post-remediation) aquifer flow conditions were used to select the 18 monitoring locations. As discussed in the next subsection, groundwater flow and particle tracking using both the VAM3D and the SWIFT groundwater modeling computer codes were used to help select the final monitoring locations identified in this plan.

4.3.4.2 VAM3D Flow Model and SWIFT Transport Model Evaluation of Well Locations

The VAM3D and SWIFT groundwater modeling codes were used to evaluate the adequacy of the density and locations of the monitoring wells planned for the GMA. The modeling effort examined the fate of a hypothetical release from each cell to the aquifer at a point directly beneath the liner-penetration box of the LCS and LDS. The modeling predicted the most likely flow path and plume configuration for particles released from the liner-penetration box area over time. The modeling was conducted for post-aquifer-remediation conditions (when groundwater flow directions would be from west to east). The original modeling was performed using the SWIFT computer code and has been updated subsequently using the VAM3D computer code. (**Note:** Modeling was performed on the assumption that there would be nine cells.)

Particle flow path modeling was conducted using the VAM3D flow model output from two model runs representing seasonal wet and dry conditions within the aquifer. Fifteen particles were seeded in a 125-ft radius around each of nine model nodes located nearest the nine cell liner-penetration box locations. These particles were tracked for a 20-year period with no retardation. The velocity flow field data from the post-aquifer-remediation scenario shows the advective particle path results (Figure 5). The particle tracks are generally from west to east beneath the OSDF. As indicated in the figure, the tracks deviate slightly in the north-south direction with seasonal water level fluctuations in the aquifer. Downgradient monitoring wells were located in the area traced out by the modeled flowpaths for each OSDF cell in order to be in the most likely position to detect a leak based on anticipated groundwater flow. These flow model results are similar to the flow model results obtained previously with the SWIFT groundwater model, which was used prior to converting to the VAM3D modeling code. Monitoring wells for Cells 1 through 3 were placed based on the results from the SWIFT groundwater flow model, and monitoring wells from Cells 4 through 8 were placed based on the results from the VAM3D flow model (DOE 2000).

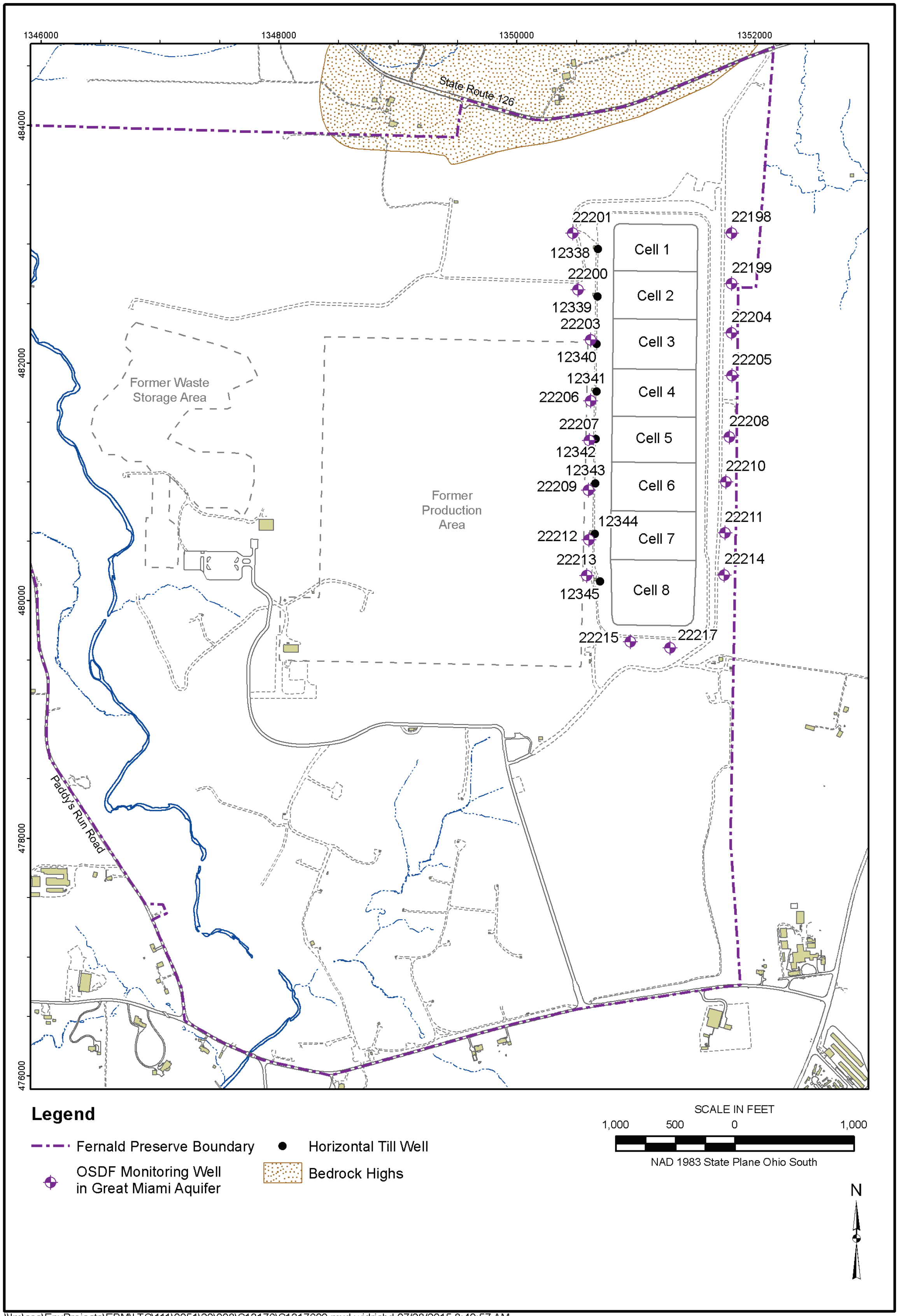

Figure 4. OSDF Well Locations

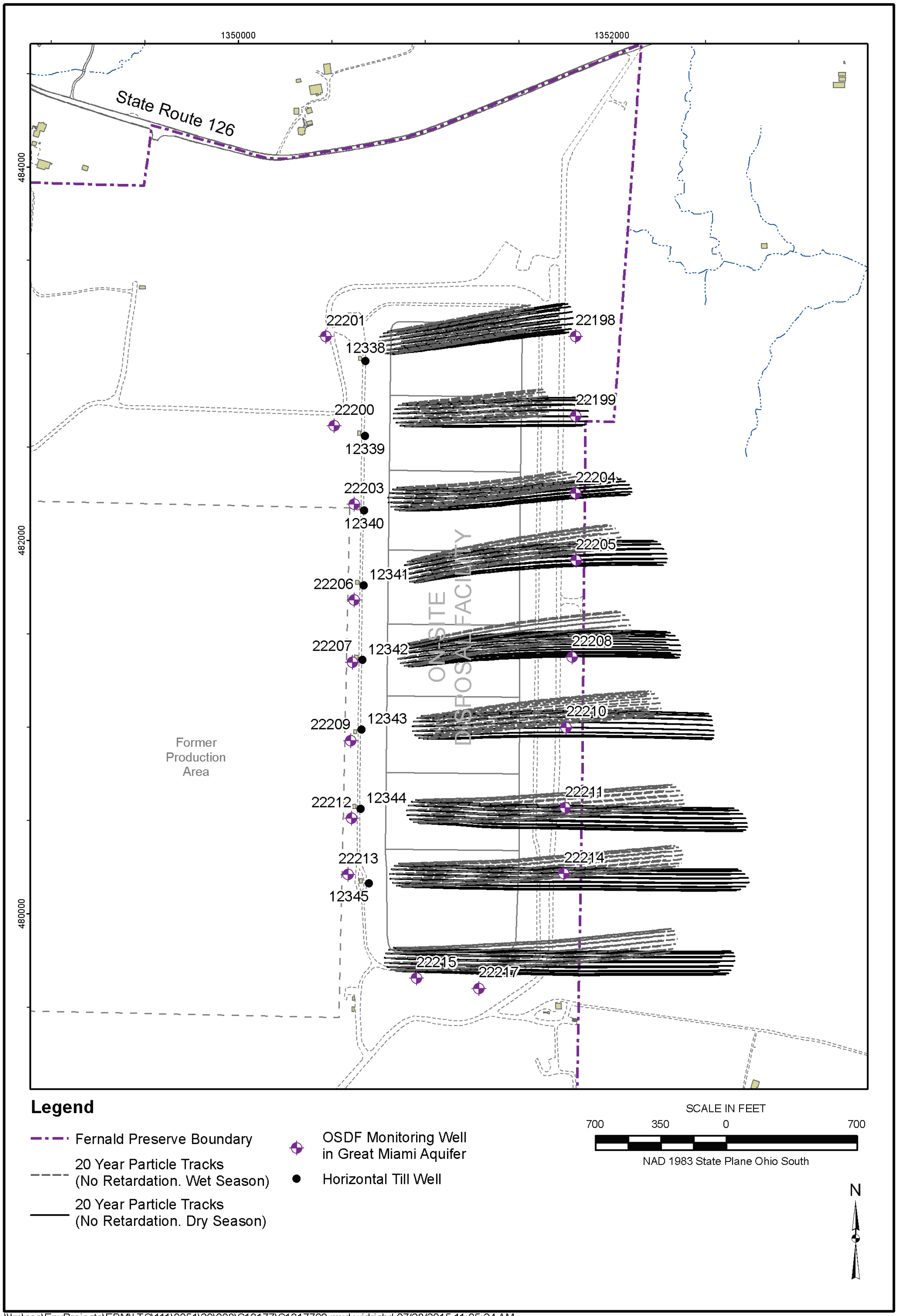

Figure 5. Post-Remediation Scenario

An earlier SWIFT model transport simulation was performed for Revision 0 of this plan to determine if the density of the downgradient GMA monitoring well network is adequate to detect the smallest contaminant plume resulting from a leak in the OSDF that would be of concern. Those SWIFT model results are included here for completeness. The SWIFT model was used to simulate a leak from the cell liner-penetration box beneath Cell 3 under natural flow gradients with no onsite pumping. Model simulations for both uranium and technetium-99 were performed. Constant loading from the cell was simulated throughout the model run such that a plume of minimum areal extent (i.e., a plume with maximum concentration equal to the FRL) was maintained in the aquifer. Hypothetical plumes of 20 parts per billion uranium and 94 picocuries per liter technetium-99 were maintained. The plumes were loaded from two hypothetical locations. One location was approximated to be beneath the cell liner-penetration box at the western edge of Cell 3 to represent the most likely leakage point from the cell. The other location was farther east, to provide a more conservative scenario where the plume would have less time to expand before the leading edge would reach the downgradient monitoring well network.

The modeling results for uranium at model year 55 (2051) and for technetium-99 at model year 30 (2026) are shown in Figure 6 and Figure 7, respectively. (**Note:** Modeling was performed on the assumption that there would be nine cells.) The durations were determined from the modeling, and they represent the period of time under constant loading for the respective plumes to disperse to the width of the spacing distance between monitoring wells (approximately equal to the OSDF cell width). Modeling results indicate that the density of downgradient GMA monitoring wells is sufficient to detect this minimal plume given the lateral expansion and the plume width under this minimal constant loading.

The width of each plume from horizontal dispersion is approximately the width of an OSDF cell, indicating that one downgradient GMA monitoring well per cell is sufficient to ensure that a GMA contaminant plume would be detected. Therefore, the configuration of GMA wells (Figure 4) is sufficient both in terms of well density and location for the OSDF leak detection monitoring program.

4.4 Sample Collection

The following subsections discuss the sample collection for the four components of the leak detection program: the LCS and the LDS drainage layers (flow and water quality), the HTWs in the glacial till (water quality), and the monitoring wells in the GMA (water quality).

4.4.1 HTW and GMA Monitoring

Sampling both the perched groundwater and the GMA groundwater during the same time frame is desired in order to enhance the comparability of the data; however, the overriding requirement is that the individual monitoring point has sufficient fluid to collect samples for a complete suite of analyses.

Prior to sample collection, the volume in the monitoring point is estimated to determine whether sufficient volume is present for the full suite of analytical parameters (refer to Appendix B for a discussion on setting priorities for low sample volume).

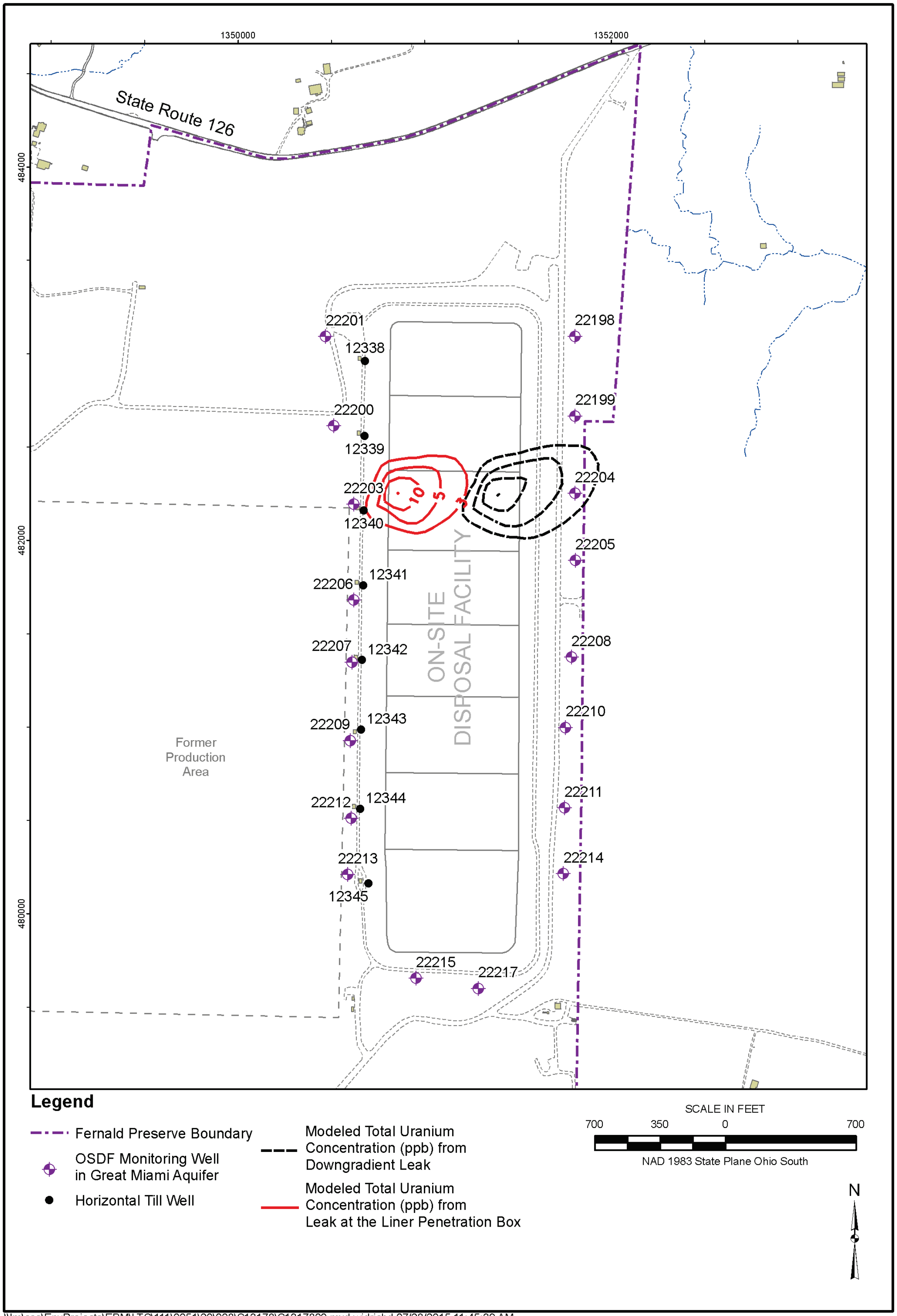

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Figure 6. SWIFT Modeling with Uranium Loading—55 Years

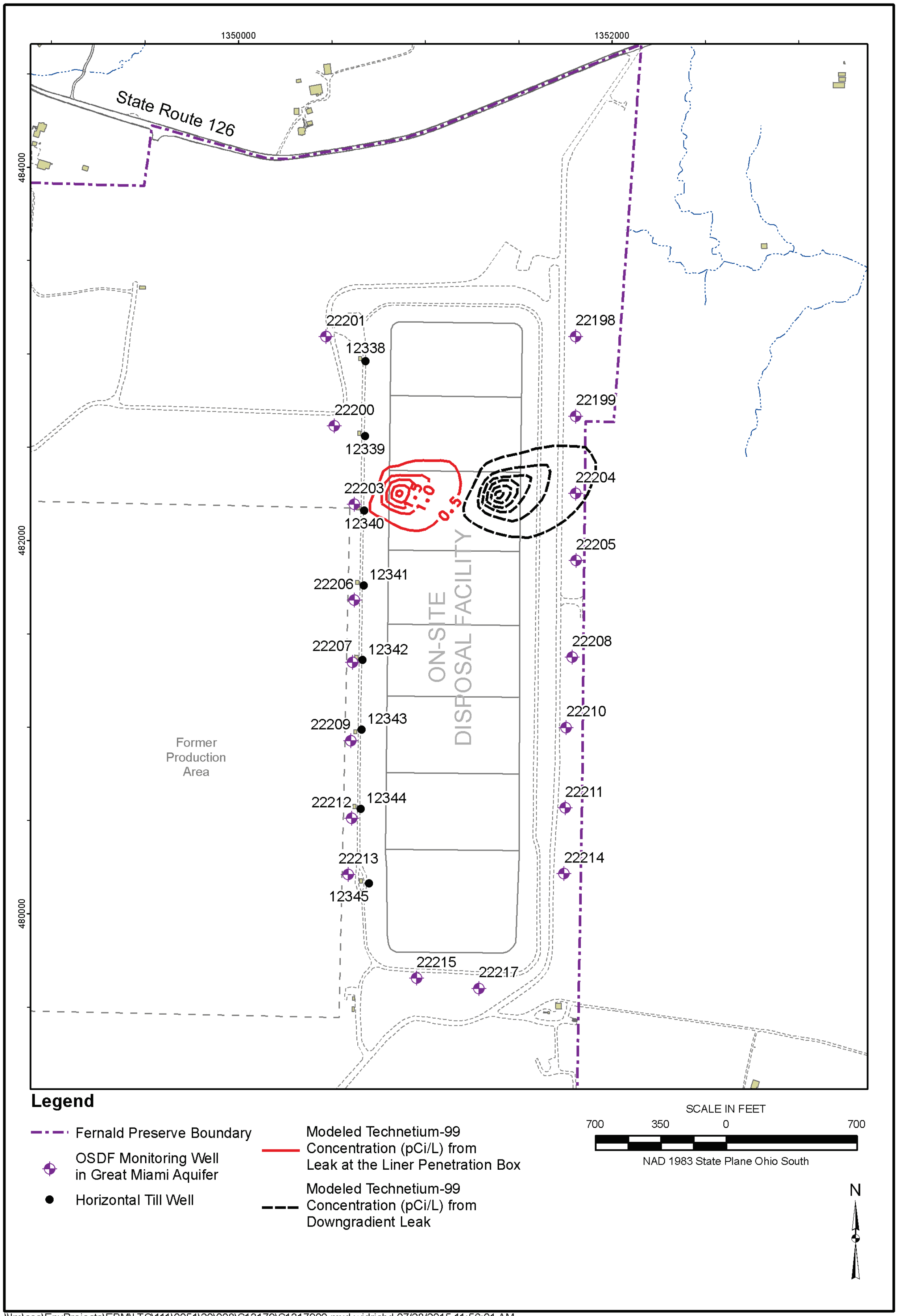

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Figure 7. SWIFT Modeling with Technetium-99 Loading—30 Years

4.4.1.1 Baseline Conditions in the Perched Groundwater and GMA

As discussed in Section 2.4, both the perched groundwater system and the GMA near the OSDF contain uranium and other Fernald Preserve–related constituents at levels above background. Monitoring data reported over the years indicate that many of the background constituent concentrations do not exhibit steady state conditions. The lack of steady state conditions complicates efforts to establish a concentration baseline. The lack of steady state conditions also complicates a determination that, on the basis of water quality data alone, a change in water quality in either the perched groundwater or GMA groundwater is due to a potential leak from the OSDF. In leak detection assessments, water quality data will be evaluated in context with preexisting contamination data and LDS flow data.

DOE's common-ion report (discussed in Section 3.2.1.2) established that several of the ions in the HTW and GMA were stable enough that a control chart could be prepared, although others remained unstable. Control charts are prepared for those constituents that meet the statistical requirements for control charting. Unstable constituent concentrations trends in the HTW and GMA are evaluated by plotting the concentration trends over time.

4.4.2 LCS/LDS Monitoring

4.4.2.1 Flow Monitoring in the LCS and LDS

Leachate collected by the LCS from each cell flows by gravity to tanks located in the valve houses where the fluid volume is measured. Flow in the LDS can be attributed to several sources (i.e., top liner leakage, construction water and compression water, consolidation water, and groundwater infiltration). If fluid is present in the LDS, it also flows by gravity to tanks located in the valve houses where its volume is measured. Fluid from the tanks is then pumped into the Enhanced Permanent Leachate Transmission System line, where it flows by gravity to the PLS then is pumped to the CAWWT for treatment.

Tank levels in each of the valve houses are monitored continuously, and valve houses are checked weekly. Continuous monitoring takes place through the Human-Machine Interface system located in the CAWWT building. Continuous monitoring of LCS/LDS flow volumes is above and beyond what is required by the OAC and CFR. Leachate pumps in the LCS/LDS tanks are set to automatically pump before the tanks are full. The set point for pump activation is approximately 80 percent of the tank capacity.

The volume of leachate pumped from the LCS/LDS tanks is recorded. Flow from each cell's LCS and LDS tanks is compiled daily and trended to provide an indication of changes in system performance. An average daily LDS flow rate (in gpad) is calculated from the monthly flow rate. Flow data are available to EPA and Ohio EPA on the Fernald Preserve website (http://www.lm.doe.gov/Fernald/Downloads.aspx) and are reported annually in the Site Environmental Report.

The LDS flow rate is monitored to ensure that the maximum design leakage rate is not exceeded. If the flow rate in the LDS exceeds the 200 gpad action leakage rate, DOE initiates notifications and response actions according to 40 CFR 264.304(b) and 40 CFR 264.304(c). Section 6.0

describes the required notifications and response actions. If the initial response leakage rate of 20 gpad is ever measured, DOE will begin the process of determining the cause of the increased flow and will evaluate the potential that a release has occurred.

4.4.2.2 Water Quality Monitoring in the LCS and LDS

Annual LCS sampling in Cells 1–8 has transitioned from including the full list of regulatory default Appendix I and PCB parameters (listed in OAC 3745-27-10) to the constituents listed in Table 1 of Appendix B.

In addition to the annual sampling described above, the LCS and LDS of Cells 1–8 are also sampled semiannually for the alternative list of 24 parameters selected through baseline monitoring, common ion studies, and statistical screening.

Details concerning the selection and approval of an alternate monitoring parameter list (beginning with initial baseline) for the OSDF are provided in Appendix E. Details concerning the selection of the common ion constituents can be found in the *Evaluation of Aqueous Ions in the Monitoring Systems of the On-Site Disposal Facility* (DOE 2008b), and details concerning the screening of additional Appendix I (of OAC 3745-27-10) and PCB parameters can be found in the 2007, 2009, 2010, and 2011 Site Environmental Reports. Appendix B provides a project-specific sampling plan that describes the current sampling program for each disposal cell.

Prior to sample collection, the volume contained in the LCS and LDS tanks or flowing through the individual LCS and LDS transfer lines is estimated in order to determine whether sufficient volume is present for the full suite of analyses (refer to the discussion in Appendix B for the setting of priorities). Although it is desirable that samples be collected from the LCS and LDS during the same time interval to enhance the comparability of the data, the overriding requirement is that the system has enough leachate/fluid volume for analysis of the full list of constituents.

An alternate list of monitoring parameters was approved for the OSDF because many of the constituents on the regulatory default list (OAC 3745-27-10) are not reasonably expected to be in or derived from the waste contained or deposited in the OSDF. Also, the chemical constituents listed in Appendix I (of OAC 3745-27-10) are typical contaminants found in sanitary landfills, and radionuclides are not included. Radionuclides are primary constituents of concern for the OSDF and need to be included in the monitoring program.

Annual monitoring in the LCS for additional Appendix I metals and inorganics parameters continues after an alternate monitoring sampling list for the OSDF was approved (initial baseline). DOE considers this continued annual sampling for additional Appendix I and PCB parameters as exceeding the requirements of Ohio Hazardous Waste and Solid Waste regulations.

A statistical analysis screening process was developed to evaluate the results of the continued additional Appendix I and PCB monitoring in the LCS. This statistical screening process was initially presented in the *Fernald Preserve 2007 Site Environmental Report*. Results from the application of this process have been presented in the 2007, 2009, 2010, and 2011 Site Environmental Reports for Cells 1–3, Cells 4 and 5, Cell 6, and Cells 7 and 8, respectively. The assessment process shows whether the average LCS concentration was greater than either the average pre-design or background concentration. If it was determined statistically that the average LCS concentration of an Appendix I or PCB constituent was greater than either the average pre-design or background concentration, then the constituent was selected for monitoring in deeper monitoring horizons on a quarterly frequency. Results for Cells 1 through 8 have identified 24 constituents.

4.5 Leak Detection Data Evaluation Process

Ohio Solid and Hazardous Waste regulations require that water quality be monitored for the purpose of determining if a leak is occurring from a disposal facility. Monitoring for a leak from the OSDF using only water quality data is challenging in that (1) the low-permeability clay beneath the facility does not readily transmit water, and (2) the presence of preexisting or background contamination and post-construction water quality changes (at below FRL levels) beneath the OSDF are still taking place, and these changes complicate the data interpretation process.

DOE has developed a strategy to meet the regulatory requirements, given the unique challenges presented by soil conditions beneath the OSDF. To evaluate the potential that a cell may be leaking, DOE will first review and compare flow rates from the LDS to the design action leakage rate to determine if sufficient hydraulic head is present in the cell to drive leachate through a liner breach. The key to a plausible potential leak determination is the presence of adequate hydraulic head (i.e., action leakage rate is present) coupled with observed water-quality changes within and beneath the facility. In leak detection assessments, water quality data will be evaluated in context with preexisting contamination data and LDS flow data. Significant changes in either water quality and/or flow rates will be investigated.

Three water quality data interpretation techniques will be used to assess changing water quality conditions in HTW and GMA wells and to compare conditions in the HTW and GMA wells to conditions inside the facility in the LCS and LDS. Concentrations will be trended over time for constituents that have not reached steady-state conditions. Control charts will be prepared for constituents that are stable. Bivariate plots will be prepared for each cell to illustrate how the water quality signature of the LCS, LDS, and HTW of a cell compare.

Ohio EPA proposed reducing the list of parameters being sampled in the HTW to just uranium, arsenic and tritium (beginning in the second quarter of 2010). Sampling for tritium in all horizons was agreed to for a year. Tritium was added to the list of constituents because it was hoped that it might serve as a useful monitoring parameter. Tritium was used in exit signs, which may be in the OSDF with other building materials. Tritium has a relatively short half-life (approx. 12 years) but is fairly mobile and if present could be a good potential leak indicator parameter. One year of tritium sampling results though showed that tritium was not a good monitoring parameter for the OSDF. Therefore, tritium is no longer sampled for in any of the monitoring horizons. In addition to sampling the HTWs for uranium and arsenic, DOE also samples for sodium and sulfate in order to prepare bivariate plots. Bivariate plots are useful in illustrating that the chemical signatures of the different monitoring horizons (LCS, LDS, HTW) are separate and distinct.

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5.0 Leachate Management Monitoring Program

With closure of the OSDF in 2006, leachate management and monitoring has transitioned from a program that addressed an operating facility actively receiving waste to a monitoring program that now addresses a closed facility no longer receiving waste. The transition has resulted in changing from sampling the LCS in Cells 1–8 for the full list of default regulatory parameters (Appendix I of OAC 3745-27-10 and PCBs) to sampling for a composite list of constituents.

Ohio Solid Waste Disposal regulations for an operating facility require an overall leak detection strategy to comply with the leachate management, monitoring, and reporting requirements in OAC 3745-27-19(M)(4) and OAC 3745-27-19(M)(5). To fulfill these requirements during the active life of the facility, the leachate management monitoring strategy needed to provide:

- A means to track the quantity of leachate collected for treatment and discharge, reported at least monthly.
- A means to verify that the engineering components of the leachate management system will operate in accordance with OAC 3745-27-19, "Operational Criteria for a Sanitary Landfill Facility."
- A description of the site-specific leachate treatment and discharge elements to ensure that leachate collected from the facility is properly managed.
- Collection and analysis of an annual leachate grab sample for Appendix I and PCB parameters according to OAC 3745-27-10 and 19.

The first item of the strategy above is fulfilled by the flow monitoring component of the leak detection monitoring strategy. Flow measurements are taken at the frequency identified in Section 4.4.2.1. The second item of the strategy above is fulfilled by the *Wastewater Treatment Outside Systems Procedure for the Fernald Preserve, Fernald, Ohio* (DOE 2014b) and the *Converted Advanced Wastewater Treatment Facility Procedure for the Fernald Preserve, Fernald, Ohio* (DOE 2014a) and Appendix D of this plan. The description in Section 5.1 fulfills the third item. The fourth item is fulfilled by sampling Cells 1–8 for an alternate parameter monitoring list.

5.1 Leachate Treatment and Discharge Management

Leachate is treated in the CAWWT and discharged at the National Pollutant Discharge Elimination System (NPDES)–permitted outfall to the Great Miami River. The following is a description of the management approach for leachate treatment, along with a description of the treatment system and the leachate monitoring needs to ensure proper operation of the treatment facility and compliance with the NPDES permit.

Leachate is collected from both the LCS and LDS layers of each cell of the OSDF whenever such fluids are present. Fluid that collects in the LCS and LDS collection tanks located in each cell's valve house is pumped to the gravity drain portion of the leachate transmission system line, which drains all valve houses to the PLS. The leachate collected in the PLS is periodically pumped to the CAWWT backwash basin or directly to CAWWT feed tanks.

Upon site closure in 2006, the CAWWT was a 1,800-gpm facility divided into a 1,200-gpm treatment train dedicated to groundwater and a 600-gpm treatment train formerly used for the treatment of storm water and remediation wastewater, including leachate. Since site storm water no longer required treatment, the CAWWT 600-gpm treatment train treated primarily groundwater but also treated leachate and water from the backwash basin.

As predicted, each year the percentage of groundwater treatment needed to achieve uranium discharge limits decreased. As of the spring of 2011, the CAWWT was being operated on an as-needed basis. In 2011, DOE, EPA, and Ohio EPA agreed to proceed with reducing the treatment capacity from approximately 1,800 gpm down to 500–600 gpm. In 2012, the throughput treatment capacity of the CAWWT was safely reduced from 1,800 gpm down to 500–600 gpm by isolating trains 1 and 2 in place to serve as spare parts for treatment train 3.

In July 2014, operational changes were made to the ongoing pump-and-treat remediation (DOE 2014c). Prior to these changes, groundwater was being treated on an as-needed basis to meet required discharge limits. In 2014, three extraction wells located in areas of the aquifer where uranium concentrations were low were no longer providing a benefit, so the wells were turned off. Pumping was increased in areas of the plume where uranium concentrations were higher. The changes resulted in an increase in the mass of uranium being removed from the aquifer. This increase resulted in the need to treat more groundwater from July to mid-November 2014, utilizing more of the existing approved groundwater treatment capacity (i.e., 600 gpm) to meet the required discharge limits.

All discharges from the CAWWT are through the NPDES Outfall PF 4001. OAC 3745-27-19, “Operational Criteria for a Sanitary Landfill Facility,” requires treatment of leachate. Leachate is a minimal flow and will likely have no bearing on operational decisions. It is required, however, that leachate be treated through the CAWWT prior to discharge to the Great Miami River until the CAWWT is no longer needed.

6.0 Reporting

6.1 Routine Reporting

Annual Site Environmental Reports will serve as the formal reporting mechanism for OSDF monitoring activities. Presenting data in one report facilitates a qualitative assessment of the impact of the OSDF on the aquifer, as well as the operational characteristics of OSDF caps and liners. Additionally, monitoring data will be made available electronically through the Geospatial Environmental Mapping System. Flow data are available to EPA and Ohio EPA upon request by contacting the site (513) 648-3334.

Reporting will include:

- LCS volumes.
- LDS accumulation rates and volumes.
- Apparent liner efficiencies.
- HTW water yields.
- LCS, LDS, HTW, and GMA water quality results.

Water quality data will be evaluated to:

- Identify if any new detects in the LCS are detected twice in a row, which would trigger sampling for the detected parameter in the LDS.
- Verify that constituents being detected in the LCS at least 25 percent of the time are being sampled for in deeper monitoring horizons.
- Identify the parameters in the HTW and GMA that meet control-charting requirements and prepare control charts for them.
- Identify the parameters in the HTW and GMA that are not stable and prepare time versus concentration plots for them.
- Prepare bivariate plots for each cell.

6.2 Notifications and Response Actions

If the flow rate into any LDS tank exceeds 20 gpad, which is 10 percent of the established OSDF action leakage rate of 200 gpad, monitoring frequency for the specific cell, including both LCS and LDS, will be increased to weekly as long as the high flow rate in the LDS remains. Leachate will be analyzed to determine concentrations of the indicator constituents. DOE will notify EPA and Ohio EPA when this situation is identified during the routine monitoring. All the monitoring data collected during the subsequent increased monitoring frequency period will be forwarded to EPA and Ohio EPA for review weekly or as it becomes available.

If the flow rate into any LDS tank exceeds 10 percent of the action leakage rate continuously in every weekly monitoring event for more than 3 months, an engineering evaluation of the integrity of the specific cell will be initiated. The cell cap and toe will be inspected for any potential problems. The perched groundwater levels in the surrounding area will also be evaluated. Any significant findings that indicate potential sources of liquid will be reported.

Appropriate maintenance actions will be identified and implemented to address any identified problems following consultation with EPA and Ohio EPA.

If the flow rate into any LDS tank exceeds the action leakage rate, the actions presented in Table 3 will be implemented. In following the steps required in Table 3, both flow volumes and concentration levels of indicator constituents in the leachate collected in the LDS will be evaluated on a cell-by-cell basis together with all the other monitoring data collected from the LCS, till monitoring wells, and GMA monitoring wells. Historical monitoring data and weather information will be compared with the current conditions to narrow the time frame of potential changes in the system performance.

Table 3. Notification and Response Actions

Step	Time frame	Action
1.	Within 7 days of the determination of an exceedance into any LDS at the action leakage rate of 200 gpad.	Notify both of the following in writing: • EPA Region 5 Regional Administrator 77 West Jackson Boulevard, Chicago, Illinois 60604-3590 • Director, Ohio Environmental Protection Agency 50 West Town Street, Suite 700, Columbus, Ohio 43215
2.	Within 14 days of the determination of an exceedance into any LDS at the action leakage rate of 200 gpad.	Submit to both of the individuals identified in Step 1 a written preliminary assessment as to the: • Amount of liquids. • Likely sources of liquids. • Possible location, size, and cause of any leaks. • Short-term actions taken and planned.
3.	As practicable to meet Step 7.	Determine to the extent practicable the location, size, and cause of any leak.
4.	As practicable to meet Step 7.	Determine any other short- or long-term actions to take to stop or mitigate the leaks.
5.	As practicable to meet Step 7.	In order to conduct Steps 3 through 5: • Assess the source of liquids, and amounts of liquids by source; and • In order to identify the source of liquids and the possible location of any leaks, and the hazard and mobility of the liquid, conduct a fingerprint, hazardous constituent, or other analyses of the liquids in the LDS; and • Assess the seriousness of any leaks in terms of potential for escaping into the environment. OR • Document why such assessments are not needed.
6.	Within 30 days of the notification given in Step 1.	Submit to both of the individuals identified in Step 1 a written report of the: • Results of the analyses and determinations made under Steps 3 through 6 (to the extent completed). • Results of action taken. • Actions ongoing (i.e., analyses and determinations under Steps 3 through 6 not yet completed) or planned (refer to Section 9.0 of the OSDF Post-Closure Care and Inspection Plan).
7.	Monthly thereafter, as long as the flow rate in the LDS exceeds the action leakage rate.	Submit to both of the individuals identified in Step 1 a written report summarizing the: • Results of actions taken. • Actions planned.

Federal Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, Subpart NC-Landfills, Response Actions, 40 CFR 264.304(b) and 265.303(b).

Preliminary field inspections of the cell caps, toes, run-on/runoff control channel, valve houses, and lift station will be conducted as soon as possible to meet the Step 7 schedule and to identify any visible signs of potential problems or sources of liquids. Pending field conditions, some mowing or snow removal may be required in order to conduct these inspections sufficiently. All necessary efforts will be made to allow sufficient visual inspections. EPA and Ohio EPA will be notified prior to these inspections. Checklists similar to those prepared for the routine quarterly inspections will be submitted as a part of the written report specified in Step 7 to document these inspections.

The Engineer on Record for the OSDF (or other engineering consultants who specialize in landfill design and are acceptable to EPA and Ohio EPA) will be requested to assist with the data evaluation, field inspections, and preparation of the report.

Preventive maintenance or any necessary repairs of selected OSDF caps or toes will be conducted based on results of routine visual inspections, engineering evaluation triggered by exceeding 10 percent of the action leakage rate continuously for three months, or the Table 3 process. If it is determined that both the cap and primary liner have failed following any of the inspections and/or engineering evaluations, then a more intensive OSDF response action will also be required. A response action might include initiating cap repair, investigating whether contamination has breached the compacted clay liner of the secondary composite liner system that lies beneath the LDS, increasing monitoring, or a combination of these actions.

Potential leakage through the clay liner below the secondary liner will be assessed by using the HTW installed beneath the liner-penetration box area and secondary liner (along with the LCS and LDS flow volumes and water quality data). If it is determined that a leak has adversely impacted groundwater (till or GMA), then a groundwater quality assessment monitoring program will be developed and initiated to determine the nature, rate, and extent of contaminant migration. Groundwater monitoring might also be increased to determine if leakage from the OSDF has entered the GMA, although given the distances involved it would be unlikely that leakage from the OSDF would be able to migrate to the GMA in the short time interval between leak detection and response.

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7.0 References

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Appendix A

On-Site Disposal Facility Applicable or Relevant and Appropriate Requirements and Other Regulatory Requirements

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Abbreviations

ANOVA	analysis of variance
ARARs	applicable or relevant and appropriate requirements
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
LDS	leak detection system
OAC	*Ohio Administrative Code*
OSDF	On-Site Disposal Facility

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Applicable or relevant and appropriate requirements (ARARs) and to-be-considered criteria—for the On-Site Disposal Facility (OSDF) groundwater detection monitoring, the OSDF leachate monitoring, and the OSDF response action—that should be addressed by this plan are provided in Table 1, as obtained from the *Final Record of Decision for Remedial Actions at Operable Unit 2* (DOE 1995e), the *Operable Unit 3 Record of Decision for Final Remedial Action* (DOE 1996d), the *Record of Decision for Remedial Actions at Operable Unit 5* (DOE 1996c), or the *Permitting Plan and Substantive Requirements for the On-Site Disposal Facility* (DOE 1996e). Additional regulatory requirements that are appropriate guidance for formulation of this plan have also been identified and included.

Table 1. OSDF Groundwater/Leak Detection and Leachate Monitoring Plan Compliance Strategy ARARs and Other Regulatory Requirements

Citation	Requirement
	PLANS
Ohio Municipal Solid Waste Rules–Sanitary Landfill Facility Permit to Install Application OAC 3745-27-06(C)(9)(a)	• Prepare a “groundwater detection monitoring plan” as required by OAC 3745-27-10, and if applicable a “groundwater quality assessment plan” and/or “corrective measures plan” required by OAC 3745-27-10.
	• Prepare a “leachate monitoring plan” to ensure compliance with OAC 3745-27-19(M)(4) and (5).
	GROUNDWATER/LEAK DETECTION MONITORING
Ohio Municipal Solid Waste Rules–Groundwater Monitoring Program for a Sanitary Landfill Facility OAC 3745-27-10(A)	(1) The owner or operator of a sanitary landfill facility shall implement a “groundwater monitoring program” capable of determining the quality of groundwater occurring within the uppermost aquifer system and all significant zones of saturation above the uppermost aquifer system underlying the landfill facility, with the following elements: (a) A “groundwater detection monitoring program” which includes: (i) a “groundwater detection monitoring plan” in accordance with OAC 3745-27-10(B) through (D); (ii) a monitoring system in accordance with OAC 3745-27-10(B); (iii) sampling and analysis procedures, including an appropriate statistical method, in accordance with OAC 3745-27-10(C); and (iv) detection monitoring procedures, including monitoring frequency and a parameter list, in accordance with OAC 3745-27-10(D). (2) Schedule for implementation of detection monitoring. (4) For purposes of this rule, the groundwater monitoring program is implemented upon commencement of sampling of groundwater wells.
Ohio Municipal Solid Waste Rules–Groundwater Monitoring System OAC 3745-27-10(B)	(1) The “groundwater detection monitoring program” shall consist of sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from both the uppermost aquifer system and any significant zones of saturation that exist above the uppermost aquifer system that: (a) represent the quality of the background groundwater that has not been affected by past or present operations; and (b) represent the quality of the groundwater passing directly downgradient of the limits of solid waste placement. (4) The number, spacing, and depth of groundwater monitoring wells shall be: (a) based on site-specific hydrogeologic information; and (b) capable of detecting a release from the facility to the groundwater at the closest practicable location to the limits of waste placement.
Ohio Municipal Solid Waste Rules–Groundwater Sampling, Analysis, and Statistical Methods OAC 3745-27-10(C)	(1) The “groundwater monitoring program” shall include consistent sampling and analysis procedures and statistical methods that are protective of human health and the environment and that are designed to ensure monitoring results that provide an accurate presentation of groundwater quality at the background and downgradient well. (a) Sampling and analysis procedures employed must be documented in a written plan. (b) The statistical method selected by the owner or operator must be in accordance with OAC 3745-27-10(C)(6)&(7). (6) After completing collection of the background data, the owner or operator shall specify one of the following statistical methods to be used in evaluating groundwater quality; the statistical method chosen must be conducted separately for each of the parameters required to be statistically evaluated: (a) a parametric analysis of variance (ANOVA); or (b) an ANOVA based on ranks; or (c) a tolerance or prediction interval procedure; or (d) a control chart approach; or (e) another statistical method.

Table 1 (continued). OSDF Groundwater/Leak Detection and Leachate Monitoring Plan Compliance Strategy ARARs and Other Regulatory Requirements

GROUNDWATER/LEAK DETECTION MONITORING (cont.)	
	(7) Performance standards for statistical methods. (a) The statistical method used to evaluate groundwater monitoring data shall be appropriate for the distribution of chemical parameters or leachate and leachate-derived constituents. If shown to be inappropriate, then the data should be transformed or a distribution free theory test should be used. If the distributions for the constituents differ, more than one statistical method may be needed. (e) The statistical method shall account for data below the limit of detection with one or more statistical procedures that ensure protection of human health and the environment. Any practical quantitation limit used in the statistical method shall be the lowest concentration level that can be reliably achieved within the specified limits of precision and accuracy during routine laboratory operating conditions that are available to the facility. (f) If necessary, the statistical method shall include procedures to control or correct for seasonal and spatial variability as well as temporal correlation in the data. (9) The number of samples collected to establish groundwater quality data shall be consistent with the appropriate statistical procedures.
Ohio Municipal Solid Waste Rules–Groundwater Detection Monitoring Program OAC 3745-27-10(D)	(2) Alternate monitoring parameter list. The owner or operator of a sanitary landfill facility may propose to delete any of the Appendix I parameters of this rule. The alternative monitoring parameter list may be approved if the removed parameters are not reasonably expected to be in or derived from the waste contained or deposited in the landfill facility. The following factors should be considered: (a) which of the parameters in Appendix I shall be deleted; (b) types, quantities, and concentrations of constituents in wastes managed at the landfill facility; (c) the concentrations of Appendix I constituents in the leachate from the relevant unit(s) of the landfill facility; (d) any other relevant information. (3) Alternate inorganic parameter list. The owner or operator of a sanitary landfill facility may propose that an alternative list of inorganic indicator parameters to be used in lieu of some or all of the inorganic parameters listed in Appendix I of this rule. The alternative inorganic indicator parameters may be approved if the alternative list will provide a reliable indication of inorganic releases from the facility to the groundwater. The following factors should be considered: (a) the types, quantities, and concentrations of constituents in wastes managed at the facility; (b) the mobility, stability, and persistence of waste constituents or their reaction products in the unsaturated zone beneath the facility; (c) the detectability of the indicator parameters, waste constituents, and their reaction products in the groundwater; and (d) the concentrations or values and coefficients of variation of monitoring parameters or constituents in the background groundwater quality. (5) Monitoring parameters, frequency, location. The owner or operator shall monitor the groundwater monitoring well system (a) and (b) during the active life of the facility (including final closure and the post-closure care period, (ii) at least semiannually by collecting: (*a*) during the initial one hundred and eighty days after implementing the groundwater detection monitoring program (the first semiannual sampling event), a minimum of four independent samples from each monitoring well. Collect and analyze a minimum of eight independent samples during the first year of sampling. *(b)* After the first year during subsequent semiannual sampling events, at least one sample for each monitoring well. (iii) beginning with receiving the results from the first monitoring event under (D)(5)(a)(ii)(b) of this rule and semiannually thereafter, by statistically analyzing the results. (6) Alternative sampling and statistical analysis frequency. The owner or operator of a sanitary landfill facility may propose an alternative frequency for groundwater sampling and/or statistical analysis. The alternative frequency may be approved provided it is not less than annual. The following factors should be considered: (a) lithology of the aquifer system and all stratigraphic units above the uppermost aquifer system; (b) hydraulic conductivity of the uppermost aquifer system and all stratigraphic units above the uppermost aquifer system; (c) groundwater flow rates for the uppermost aquifer system and all zones of saturation above the uppermost aquifer system; (d) minimum distance between the upgradient edge of the limits of waste placement of the landfill facility and the downgradient monitoring well system; and (e) resource value of the uppermost aquifer system. NOTE: Table B-3 on page B.3-25 of the *Record of Decision for Operable Unit 5* states, “an alternate list of monitoring parameters will be required.”

Table 1 (continued). OSDF Groundwater/Leak Detection and Leachate Monitoring Plan Compliance Strategy ARARs and Other Regulatory Requirements

GROUNDWATER/LEAK DETECTION MONITORING (Cont.)	
Ohio Hazardous Waste General Facility Standard–New Facilities Rules–Required Programs OAC 3745-54-91; 40 CFR 264.91	Owners or operators subject to the groundwater protection rules must conduct a monitoring and response program as follows: (1) whenever hazardous constituents from a regulated unit are detected at the compliance point, the owner or operator must institute a compliance monitoring program. “Detected” is defined as statistically significant evidence of contamination. (2) whenever the groundwater protection standard is exceeded, the owner or operator must institute a corrective action program. “Exceeded” is defined as statistically significant evidence of increased contamination. (3) whenever hazardous constituents from a regulated unit exceed concentration limits in groundwater between the compliance point and the downgradient facility property boundary, the owner or operator must institute a corrective action program. (4) in all other cases, the owner or operator must institute a detection monitoring program.
Ohio Hazardous Waste General Facility Standards–New Facilities Rules–Groundwater Protection Standard OAC 3745-54-92; 40 CFR 264.92	The owner or operator must comply with conditions specified in the facility permit that are designed to ensure that hazardous constituents detected in the groundwater from a regulated unit do not exceed the specified concentration limits (specified in the permit) in the uppermost aquifer underlying the waste management area beyond the point of compliance. The groundwater protection standard will be established when hazardous constituents have been detected in the groundwater.
Ohio Hazardous Waste General Facility Standards–New Facilities Rules–Hazardous Constituents OAC 3745-54-93; 40 CFR 264.93	(A) The permit will specify the hazardous constituents to which the groundwater protection standard applies. Hazardous constituents are those that have been detected in the groundwater in the uppermost aquifer underlying a regulated unit and that are reasonably expected to be in or derived from waste contained in a regulated unit, unless excluded under paragraph B of this rule. (B) A constituent will be excluded from the list of hazardous constituents specified in the facility permit if it is found that the constituent is not capable of posing a substantial present or potential hazard to human health or the environment. The following will be considered: (1) Potential adverse effects on groundwater quality, considering: (a) the physical and chemical characteristics of the waste in the regulated unit, included its potential for migration; (b) the hydrogeological characteristics of the facility and surrounding land; (c) the quantity of groundwater and the direction of groundwater flow; (d) the proximity and withdrawal rates of groundwater users; (e) the current and future use of groundwater in the area; (f) the existing quality of groundwater, including other sources of contamination and their cumulative impact on the groundwater quality; (g) the potential for health risks caused by human exposure to waste constituents; (h) the potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents; (i) the persistence and permanence of the potential adverse effects.
Ohio Hazardous Waste General Facility Standards–New Facilities Rules–General Groundwater Monitoring Requirements OAC 3745 54 97; 40 CFR 264.97	(G) In detection monitoring or where appropriate in compliance monitoring, data on each constituent specified in the permit [or in the monitoring plan] is to be collected from background wells and wells at compliance point(s). The number and kinds of samples collected to establish background shall be appropriate for the form of statistical test employed. The sample size should be as large as necessary to ensure with reasonable confidence that a contaminant release to the groundwater from a facility will be detected. The owner or operator will determine an appropriate sampling procedure and interval for each constituent. (H) The owner or operator is to specify one of the following statistical methods to be used in evaluating groundwater monitoring data for each constituent to be specified. Use of any of the following statistical methods must be protective of human health and the environment: (1) a parametric ANOVA; (2) an ANOVA based on ranks; (3) a tolerance or prediction interval procedure; (4) a control chart approach; or (5) another statistical method.

Table 1 (continued). OSDF Groundwater/Leak Detection and Leachate Monitoring Plan Compliance Strategy ARARs and Other Regulatory Requirements

GROUNDWATER/LEAK DETECTION MONITORING (Cont.)	
Ohio Hazardous Waste General Facility Standards–New Facilities Rules–Detection Monitoring Program OAC 3745-54-98; 40 CFR 264.98	(A) The owner or operator must monitor for indicator parameters (e.g., specific conductance, total organic carbon, or total organic halogens, waste constituents, or reaction products that provide a reliable indication of the presence of hazardous constituents in groundwater. The director (of the Ohio Environmental Protection Agency [Ohio EPA]) will specify the parameters or constituents to be monitored in the facility permit, after considering the following factors: (1) types, quantities, and concentrations of constituents to be managed at the regulated unit; (2) mobility, stability, and persistence of the waste constituents or their reaction products in the unsaturated zone beneath the waste management area; (3) detectability of the indicator parameters, waste constituents, and their reaction products in the groundwater; and (4) concentrations or values and coefficients of variation of proposed monitoring parameters or constituents in the groundwater background. (D) The permit will specify the frequencies for collecting samples and conducting statistical tests to determine whether there is statistically significant evidence of contamination for any parameter or hazardous constituent specified in the permit. (F) The owner or operator must determine whether there is statistically significant evidence of contamination for any chemical parameter or hazardous constituent specified in the permit at the frequency specified in the permit.
Federal Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings: Subpart D–Standards for Management of Uranium Byproduct Material Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended 40 CFR 192.30 through 34	Uranium byproduct materials shall be managed to conform to the groundwater protection standard in 40 CFR 264.92, which includes detection monitoring. Alternate concentration limits for uranium can be established, as described in 40 CFR 264.95 and 264.94(b).
Environmental Monitoring DOE M 435.1-1	I.1.E.(7) Environmental Monitoring. Radioactive waste management facilities, operations, and activities shall meet the environmental monitoring requirements of DOE 5400.1, General Environmental Protection Program; and DOE 5400.5, Radiation Protection of the Public and the Environment. IV.R.(3)(a) The site-specific performance assessment and composite analysis shall be used to determine the media, locations, radionuclides, and other substances to be monitored. IV.R.(3) Disposal Facilities. (C) The environmental monitoring programs shall be capable of detecting changing trends in performance to allow application of any necessary corrective action prior to exceeding the performance objectives in this Chapter.
LEACHATE MANAGEMENT AND MONITORING	
Ohio Municipal Solid Waste Rules–Operational Criteria for a Sanitary Landfill Facility OAC 3745-27-19(M)(4)&(5)	The owner annually shall report: • a summary of the quantity of leachate collected for treatment and disposal on a monthly basis during the year; location of leachate treatment and/or disposal; and verification that the leachate management system is operating in accordance with this rule; • results of analytical testing of an annual grab sample of leachate.
OTHER REQUIREMENTS	
Federal Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, Subpart N–Landfills, Monitoring and Inspection 40 CFR 264.302	Action Leakage Rate: (a) The action leakage rate is the maximum design flow rate that the leak detection system (LDS) can remove without the fluid head on the bottom liner exceeding 1 ft. The action leakage rate must include an adequate safety margin to allow for uncertainties in the design (e.g., slope, hydraulic conductivity, thickness of drainage material), construction, operation, and location of the LDS, waste and leachate characteristics, likelihood and amounts of other sources of liquids in the LDS, and proposed response actions (e.g., the action leakage rate must consider decreases in the flow capacity of the system over time resulting from siltation and clogging, rib layover and creep of synthetic components of the system overburden pressures, etc.). (b) To determine if the action leakage rate has been exceeded, the owner or operator must convert the weekly or monthly flow rate from the monitoring data obtained under 40 CFR 264.303(c), to an average daily flow rate (gallons per acre per day) for each sump (i.e., liner-penetration box). Unless the U.S. Environmental Protection Agency (EPA) approves a different calculation, the average daily flow rate for each sump must be calculated weekly during the active life and closure period, and monthly during the post-closure care period when monthly monitoring is required under 40 CFR 264.303(c).

Table 1 (continued). OSDF Groundwater/Leak Detection and Leachate Monitoring Plan Compliance Strategy ARARs and Other Regulatory Requirements

OTHER REQUIREMENTS (Cont.)	
Federal Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, Subpart N–Landfills, Monitoring and Inspection 40 CFR 264.303(c)	An owner or operator required to have a LDS must record the amount of liquids removed from each LDS sump as follows: (1) During the active life and closure period, at least once each week. (2) After the final cover is installed, in accordance with the following graded approach: • at least monthly; or • if the liquid level in the sump stays below the pump operating level for two consecutive months, at least quarterly; or • if the liquid level in the sump stays below the pump operating level for two consecutive quarters, at least semiannually; but • if at any time during the post-closure care period the pump operating level is exceeded at units on quarterly or semiannual recording schedules, the owner or operator must return to monthly recording of amounts of liquids removed from each sump until the liquid level again stays below the pump operating level for two consecutive months. NOTE: There are no requirements in Ohio hazardous waste or Ohio solid waste rules regarding LDS flow monitoring.
Federal Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, Subpart N–Landfills, Response Actions 40 CFR 264.304	(a) The owner or operator of landfill units subject to 264.301(c) or (d) must have an approved response action plan before receipt of waste. The response action plan must set forth the action to be taken if the "action leakage rate" has been exceeded [in any LDS sump]. (b) At a minimum, the response action plan [see entry 2 above] must describe the following actions to be taken: (1) Notify the Regional Administrator in writing of the exceedance within 7 days of the determination; (2) Submit a preliminary written assessment to the Regional Administrator within 14 days of the determination, as to the amount of liquids, likely sources of liquids, possible location, size, and cause of any leaks, and short-term actions taken and planned; (3) Determine to the extent practicable the location, size, and cause of any leak; (4) Determine whether waste receipt should cease or be curtailed, whether any waste should be removed from the unit for inspection, repairs, or controls, and whether or not the unit should be closed; (5) Determine any other short-term or longer-term actions to be taken to mitigate or stop any leaks; and (6) Within 30 days of the notification that the action leakage rate has been exceeded, submit to the Regional Administrator the results of the analysis specified in (3), (4), and (5) [above], the results of action taken, and actions planned. Monthly thereafter, as long as the flow rate in the LDS exceeds the action leakage rate, the owner or operator must submit to the Regional Administrator a report summarizing the results of any RAs taken and actions planned. (c) To make the leak and/or RA determinations in paragraphs (b)(3), (4) and (5) [above], the owner or operator must: • Asses the source of liquids, and amount of liquids by source; • Conduct a fingerprint, hazardous constituent, or other analyses of the liquids in the LDS to identify the source of liquids and possible location of any leaks, and the hazard and mobility of the liquid; and • Assess the seriousness of any leaks in terms of potential for escape to the environment; or • Document why such assessments are not needed.

Appendix B

Project-Specific Plan for the On-Site Disposal Facility Monitoring Program

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Contents

Figure

Tables

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Abbreviations

ASL	analytical support level
CAWWT	Converted Advanced Wastewater Treatment facility
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FPQAPP	*Fernald Preserve Quality Assurance Project Plan*
GMA	Great Miami Aquifer
GWLMP	Groundwater/Leak Detection and Leachate Monitoring Plan
HTW	horizontal till well
LCS	leachate collection system
LDS	leak detection system
LMS	Legacy Management Support
mg/L	milligrams per liter
mL	milliliter
OSDF	On-Site Disposal Facility
pCi/L	picocuries per liter
RDL	reportable detection limit
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TOX	Total Organic Halogens
µg/L	micrograms per liter

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1.0 Introduction

1.1 Purpose

The purpose of this plan is to provide detailed information for samplers to collect data to support the analytical and reporting requirements described in the On-Site Disposal Facility (OSDF) Groundwater/Leak Detection and Leachate Monitoring Plan (GWLMP). The GWLMP divides the OSDF monitoring program into two primary elements: (1) a leak detection component, which will provide information to verify the OSDF's ongoing performance, its integrity, and its impact on groundwater; and (2) a leachate monitoring component, which will satisfy requirements for leachate collection and management. This plan discusses requirements for sampling the groundwater monitoring system (i.e., horizontal till wells [HTWs] and Great Miami Aquifer [GMA] wells), leachate collection system (LCS), and leak detection system (LDS). All sampling and analysis activities will be consistent with the data quality objective provided in Appendix C of the GWLMP.

1.2 Scope

The leak detection monitoring strategy recognizes the various operating phases of the OSDF, including periods before, during, and after waste placement. The facility is currently in the post-closure phase. Each cell has been constructed with an LCS to collect infiltrating rainwater and an LDS to provide early detection of leakage within the individual cells. Additionally, groundwater within the glacial till is monitored using a series of HTWs constructed beneath each cell, and the GMA is monitored by conventional monitoring wells located upgradient and downgradient of each OSDF cell. Monitoring locations for the eight cells are identified in Figure 1.

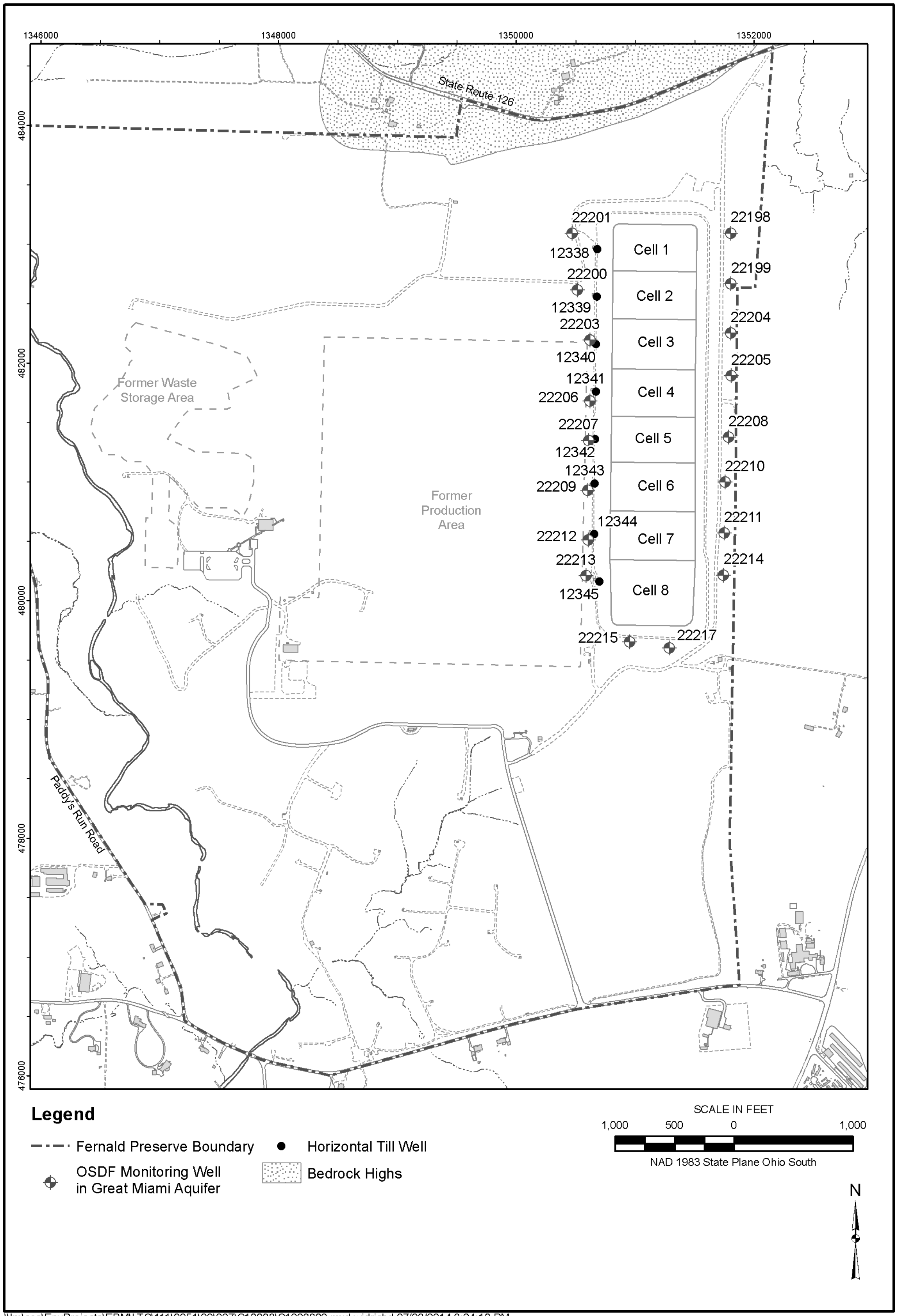

Figure 1. OSDF Well Locations

2.0 Sampling Program

As noted in Section 3.0 of the GWLMP, the Ohio Solid Waste regulations require that, for detection monitoring, at least four independent samples from each well will be taken during the first 180 days after implementation of the groundwater detection monitoring program and at least eight independent samples in the first year to determine the background (baseline) water quality (*Ohio Administrative Code* 3745-27-10[D][5][a][ii][a]). The requirement to collect eight independent samples is only applicable to those wells installed after August 15, 2003, because that is the date that the code became effective. The HTWs and GMA wells were sampled bimonthly after waste placement until 12 samples were collected. This frequency was selected to address OSDF construction schedules while the OSDF was under construction, to develop an appropriate statistical procedure, and to compensate for varying temporal conditions and seasonal fluctuations. After a sufficient number of samples were collected for statistical analysis, samples were collected quarterly from the HTWs and the GMA through 2013. Beginning in January 2014, sampling frequency was reduced from quarterly to semiannual.

Specific monitoring requirements for each cell are provided in Section 2.1, and the specific analytical parameters are listed in Tables 1 through 3. Analytical methods have been chosen to achieve the lowest detection limits possible for the constituents of concern in the OSDF. A summary of sampling requirements for each OSDF cell is presented in Table 4.

2.1 Sampling at All Cells

Sampling will be as follows:

- Annual samples will be collected from the LCS of Cells 1–8 for the parameters listed in Table 1.
- Semiannual samples will be collected from the LCS, LDS, and GMA wells of Cells 1–8 for the parameters listed in Table 2.
- Semiannual samples will be collected from all HTWs for the parameters listed in Table 3.

If an analyte is detected in the annual sample from a cell's LCS, and the analyte is not being sampled for in the cell's LDS, then confirmatory sampling will be conducted for that constituent in the cell's LCS during the next sampling round. Two consecutive detects in a cell's LCS will trigger sampling in the cell's LDS during the next scheduled sampling event. Two consecutive detects in the cell's LDS will trigger sampling in the cell's GMA wells. The requirements for this confirmatory sampling will be documented and approved through the established variance process.

Table 1. Annual LCS Monitoring List Requirements for Cells 1 through 8

Parameter	RDL[a]	Method	Priority[b]	ASL	Holding Time	Preservation	Standard Volume	Minimum Volume	Container
Radionuclides:	(pCi/L)								
Technetium-99	15	Liquid Scint.[c]	2	D	6 months	HNO_3 to pH<2	1 L	500 mL	Plastic or Glass
Inorganics:	(mg/L)								
Antimony	0.003	SW-846[d]	1	D	6 months	HNO_3 to pH<2	1 L	600 mL	Plastic or Glass
Arsenic	0.020								
Barium	0.020								
Beryllium	0.001								
Boron	0.010								
Cadmium	0.001								
Calcium	5.00								
Chromium	0.002								
Cobalt	0.030								
Copper	0.008								
Iron	0.100								
Lead	0.002								
Lithium	0.002								
Magnesium	5.00								
Manganese	0.005								
Nickel	0.020								
Potassium	5.00								
Selenium	0.005								
Silver	0.001								
Sodium	5.00								
Thallium	0.004								
Uranium	0.0002								
Vanadium	0.020								
Zinc	0.015								
Mercury	0.0001				28 days				

Table 1 (continued). Annual LCS Monitoring List Requirements for Cells 1 through 8

Parameter	RDL[a]	Method	Priority[b]	ASL	Holding Time	Preservation	Standard Volume	Minimum Volume	Container
Volatile Organics:	(µg/L)								
Bromodichloromethane	10	SW-846[d]	4	D	14 days	Cool to 4 °C With H_2SO_4, HCL, or solid $NaHSO_4$ to pH<2	3 × 40 mL	1 × 40 mL	Glass Vial with Teflon-lined Septum Cap[e]
1,1-Dichloroethene	5								
1,2-Dichloroethene (Total)	10								
Tetrachloroethene	10								
Trichloroethene	3								
Vinyl Chloride	1								
Semi-Volatile Organics:	(µg/L)								
Carbazole	10	SW-846[d]	7	D	7 days to extraction/ 40 days from extraction to analysis	Cool to 4 °C	1 L	1L	Amber Glass Bottle with Teflon-lined Cap
4-Nitroaniline	50								
Bis(2-Chloroisopropyl)ether	5								
Pesticides:	(µg/L)								
alpha-Chlordane	0.05	SW-846[d]	8	D	7 days to extraction/ 40 days from extraction to analysis	Cool to 4 °C	1 L	1 L	Amber Glass Bottle with Teflon-lined Cap
General Chemistry:	(mg/L)								
Ammonia	0.1	350.1[g], 350.3[g], 4500C[h], 4500F[h]	13	D	28 days	Cool to 4 °C, H_2SO_4 to pH<2	500 mL	200 mL	Plastic
Total Organic Halogens (TOX)	0.025	9020B[d]	5	D	28 days	Cool to 4 °C, H_2SO_4 to pH<2	500 mL	20 mL	Amber Glass Bottle with Teflon-lined cap[f]
Total Organic Carbon (TOC)	1	9060[d], 5310B[h]	6	D	28 days	Cool to 4 °C, H_2SO_4 to pH<2	250 mL	125 mL	Amber Glass Bottle with Teflon-lined cap
Chloride	0.5	325.2[g], 300(all)[g]	11	D	28 days	Cool to 4 °C	250 mL	100 mL	Plastic
Nitrate/Nitrite	0.05	353.1[g], 353.2[g], 4500D[h], 4500E[h]	9	D	28 days	Cool to 4 °C, H_2SO_4 to pH<2	100 mL	20 mL	Plastic or Glass

Table 1 (continued). Annual LCS Monitoring List Requirements for Cells 1 through 8

Parameter	RDL[a]	Method	Priority[b]	ASL	Holding Time	Preservation	Standard Volume	Minimum Volume	Container
Sulfate	0.5	375.2[g], 300.0[g], 4500E[h]	12	D	28 days	Cool to 4 °C	250 mL	100 mL	Plastic
Total Dissolved Solids (TDS)	10	160.1[g], 2540C[h]	10	D	7 days	Cool to 4 °C	500 mL	250 mL	Plastic or Glass
Total Alkalinity	1	310.1[g], 2320B[h]	14	D	14 days	Cool to 4 °C	500 mL	250 mL	Plastic

Note: Field parameters are performed at each sampling location prior to sample collection and include dissolved oxygen, ORP, pH, specific conductance, temperature, and Turbidity at ASL A, Priority 1.

[a] RDL = Required Detection Limit.

[b] If sufficient volume is not available for collection of a full suite at standard volume, then the minimum volume and priority will be used to maximize the number of analytical groups collected. The prioritization is based upon uranium being the most important parameter. After that, the prioritization is based upon sample volatilization.

[c] Radiological analyses do not have standard methods; however, the performance-based analytical specifications for these parameters are provided in the FP QAPP. (Liquid Scint. = Liquid Scintillation).

[d] *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA 1998).

[e] No head space.

[f] Minimal head space – as close to zero as possible.

[g] *Methods for Chemical Analysis of Water and Wastes* (EPA 1983).

[h] *Standard Methods for Analysis of Water and Wastewater*, 17th edition (APHA 1989).

Table 2. Semiannual LCS, LDS, and GMA Monitoring List Requirements for Cells 1 through 8

Parameter	RDL[a]	Method	Priority[b]	ASL	Holding Time	Preservation	Standard Volume	Minimum Volume	Container
Radionuclides	(pCi/L)								
Technetium-99[c]	15	Liquid Scint.[d]	2	D	6 months	HNO_3 to pH<2	1 L	500 mL	Plastic or Glass
Inorganics:	(mg/L)								
Arsenic	0.020	SW-846[e]	1	D	6 months	HNO_3 to pH<2	1 L	600 mL	Plastic or Glass
Barium	0.020								
Boron	0.010								
Cadmium[f]	0.001								
Calcium	5.00								
Chromium	0.002								
Cobalt	0.030								
Copper	0.008								
Iron	0.100								
Lithium	0.002								
Magnesium	5.00								
Manganese	0.005								
Nickel	0.020								
Potassium	5.00								
Selenium	0.005								
Sodium	5.00								
Uranium	0.0002								
Zinc	0.015								
Volatile Organics	(µg/L)								
1,1-Dichloroethene[g]	5	SW-846[e]	4	D	14 days	Cool to 4 °C, with H_2SO_4, HCl, or solid $NaHSO_4$ to pH<2	3 x 40 mL	1 x 40 mL	Glass vial with Teflon-lined septum cap[h]
General Chemistry:	(mg/L)								
Ammonia[g]	0.1	350.1[i], 350.3[i], 4500C[j], 4500F[j]	11	D	28 days	Cool to 4 °C, H_2SO_4 to pH<2	500 mL	200 mL	Plastic
Total Organic Halogens (TOX)	0.025	9020B[e]	5	D	28 days	Cool to 4 °C, H_2SO_4 to pH<2	500 mL	20 mL	Amber Glass Bottle with Teflon-lined cap[k]

Table 2 (continued). Semiannual LCS, LDS, and GMA Monitoring List Requirements for Cells 1 through 8

Parameter	RDL[a]	Method	Priority[b]	ASL	Holding Time	Preservation	Standard Volume	Minimum Volume	Container
General Chemistry (continued):	(mg/L)								
Total Organic Carbon (TOC)	1	9060[e], 5310B[j]	6	D	28 days	Cool to 4 °C, H_2SO_4 to pH<2	250 mL	125 mL	Amber Glass Bottle with Teflon-lined cap
Chloride	0.5	325.2[i], 300(all)[i]	9	D	28 days	Cool to 4 °C	250 mL	100 mL	Plastic
Nitrate/Nitrite	0.05	353.1[i], 353.2[i], 4500D[j], 4500E[j]	7	D	28 days	Cool to 4 °C, H_2SO_4 to pH<2	100 mL	20 mL	Plastic or Glass
Sulfate	0.5	375.2[i], 300.0[i], 4500E[j]	10	D	28 days	Cool to 4 °C	250 mL	100 mL	Plastic
Total Dissolved Solids (TDS)	10	160.1[i], 2540C[j]	8	D	7 days	Cool to 4 °C	500 mL	250 mL	Plastic or Glass
Total Alkalinity	1	310.1[i], 2320B[j]	12	D	14 days	Cool to 4 °C	500 mL	250 mL	Plastic

Note: Field parameters are performed at each sampling location prior to sample collection and include dissolved oxygen, ORP, pH, specific conductance, temperature, and Turbidity at ASL A, Priority 1.

[a] RDL = Required Detection Limit

[b] If sufficient volume is not available for collection of a full suite at standard volume, then the minimum volume and priority will be used to maximize the number of analytical groups collected. The prioritization is based upon uranium being the most important parameter. After that, the prioritization is based upon sample volatilization.

[c] Technetium-99 is monitored at Cell 8 only.

[d] Radiological analyses do not have standard methods; however, the performance-based analytical specifications for these parameters are provided in the FP QAPP. (Liquid Scint. = Liquid Scintillation)

[e] *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA 1998).

[f] Cadmium is monitored at the Cell 8 LDS only.

[g] Ammonia has been added to the Cell 3 LDS and 1,1-dichloroethene has been added to the Cells 7 and 8 LDS per the requirements discussed under Section 2.1, page 3. Both parameters had back-to-back detections in the LCS; therefore, semiannual sampling in the next lowest horizon (i.e., LDS) is required.

[h] No head space.

[i] *Methods for Chemical Analysis of Water and Wastes* (EPA 1983).

[j] *Standard Methods for Analysis of Water and Wastewater*, 17th edition (APHA 1989).

[k] Minimal head space – as close to zero as possible.

Table 3. Semiannual HTW Monitoring List Requirements for Cells 1 through 8

Parameter	RDL[a]	Method	Priority[b]	ASL	Holding Time	Preservation	Standard Volume	Minimum Volume	Container
Inorganics:	(mg/L)								
Arsenic	0.020	SW-846[c]	1	D	6 months	HNO_3 to pH<2	1 L	600 mL	Plastic or Glass
Sodium	5.00								
Uranium	0.0002								
General Chem.:	(mg/L)								
Sulfate	0.5	375.2[d], 300.0[d], 4500E[e]	2	D	28 days	Cool to 4 °C	250 mL	100 mL	Plastic

Note: Field parameters are performed at each sampling location prior to sample collection and include dissolved oxygen, ORP, pH, specific conductance, temperature, and Turbidity at ASL A, Priority 1.

[a] RDL = Required Detection Limit.

[b] If sufficient volume is not available for collection of a full suite at standard volume, then the minimum volume and priority will be used to maximize the number of analytical groups collected. The prioritization is based upon uranium being the most important parameter. After that, the prioritization is based upon sample volatilization.

[c] *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA 1998).

[d] *Methods for Chemical Analysis of Water and Wastes* (EPA 1983).

[e] *Standard Methods for Analysis of Water and Wastewater*, 17th edition (APHA 1989).

Table 4. Summary of Sampling Requirements for the OSDF

Cell(s)	Monitoring Horizons[a]	Annually[b]	Semiannually
1 through 8	LCS	Table 1	Table 2
	LDS, GMA	NA	Table 2
	HTW	NA	Table 3

[a] LCS = leachate collection system
LDS = leak detection system
HTW = horizontal till well
GMA = Great Miami Aquifer
[b] NA = not applicable

2.2 Additional Sampling Requirements

All horizons for a particular cell will be sampled during the same time frame to enhance the comparability of the data. If insufficient volume is available for collection of the entire analytical suite, the sample sets shall be collected in accordance with the priorities listed in Tables 1 through 3. Samples will be collected from the HTWs, GMA wells, LCS, and LDS in accordance with the *Fernald Preserve Quality Assurance Project Plan* (FPQAPP) (DOE 2014) and the *Fernald Preserve and Mound, Ohio, Sites Environmental Monitoring Procedures* (DOE 2015).

2.3 LCS and LDS Sample Collection

Samples from the LCS and LDS shall be collected by entering the valve houses located on the western side of each cell. Samples will be collected directly from the sample ports on the bottom of the LCS and LDS as the lines enter the eastern side of the valve house. The LCS is located on the northern side of the valve house, and the LDS is located on the southern end of the valve house. No purging of the line is required prior to sample collection. If the discharge line is dry or does not yield enough water for the entire sample suite, the sample will be collected from the LCS and LDS tanks located within the valve house. The samples from the tanks will be collected using a dedicated Teflon bailer. If the sample is collected from the LCS or LDS tank, the tank will be pumped down to a low level after the sample is collected to help ensure the next quarterly sample is representative.

2.4 HTW Sample Collection

The glacial till is monitored under each cell using horizontal wells installed during construction of each cell. Prior to sample collection, each HTW shall be purged of three well volumes or purged to dry, whichever occurs first. Sample collection from the horizontal well shall be accomplished using a Teflon bailer.

2.5 Great Miami Aquifer Sample Collection

Each cell is monitored by two GMA wells, located east and west of each individual cell. Two additional GMA wells are located on the south side of Cell 8. These wells are sampled using dedicated sampling equipment.

Filtering of groundwater samples at monitoring wells may take place on a case-by-case basis if deemed appropriate. If filtering is conducted, the reasons for filtering will be presented to U.S. Environmental Protection Agency (EPA) and Ohio Environmental Protection Agency (Ohio EPA) annually through the Site Environmental Report. Ohio EPA will be notified as soon as possible via email (tom.schneider@epa.ohio.gov or designee).

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3.0 Additional Sampling Program Requirements

3.1 Quality Assurance Requirements

Quality assurance requirements are consistent with those identified in the FPQAPP. Self-assessment and independent assessments of work processes and operations will be conducted to ensure quality of performance. Self-assessments will evaluate sampling procedures and paperwork associated with the sampling effort. Independent assessments will be performed by a Quality Assurance representative by conducting surveillances. Surveillances will be performed at least once per year at any time during the project and will consist of monitoring/observing ongoing project activity and work areas to verify conformance to specified requirements.

3.2 Changes to the Project-Specific Plan

Changes to this plan will be at the discretion of the project team leader. Prior to implementation of field changes, the project team leader or designee shall be informed of the proposed changes and circumstances substantiating the changes. Any changes to the medium-specific plan must have written approval by the project team leader or designee, Quality Assurance representative, and the field manager prior to implementation. If a Variance/Field Change Notice is required, it will be completed in accordance with the FPQAPP. The Variance/Field Change Notice form shall be issued as a controlled distribution to team members and will be included in the field data package to become part of the project record. During revisions to the Legacy Management and Institutional Controls Plan and GWLMP, Variance/Field Change Notices will be incorporated to update the plan.

If a change represents a significant change to the scope of the plan, approval would be requested through monthly conference calls with EPA and Ohio EPA. Afterward, a Variance/Field Change Notice that documents the change and the justification for the change will be provided to EPA and Ohio EPA.

3.3 Quality Control Samples

Quality control sample analyses are required as part of the GWLMP for the OSDF. A minimum of one set of field quality control samples is required for each sampling round. A “sampling round” refers to collection of samples from one or more locations for a specific project during a specified time period for a similar purpose. Duplicate and rinsate samples will be collected at a rate of one per sampling round or one per 20 samples, whichever is more frequent. Trip blanks will be collected one per day per team when samples are collected for volatile organic analysis. A rinsate sample will not be required for those locations with dedicated sample collection equipment. One matrix spike/matrix spike duplicate will be analyzed at a frequency of one per sampling event or one per 20 samples, whichever is more frequent. Quality control samples will be analyzed for the same analytes as the normal samples.

3.4 Equipment Decontamination

All nondedicated sampling equipment shall be decontaminated according to the FPQAPP prior to sample collection at each sample location. Sampling equipment shall also be decontaminated upon completion of sampling activities, unless equipment has been dedicated to the sample location.

3.5 Disposal of Wastes

During sampling activities, waste will be generated in various forms; disposal of all waste will be in accordance with site requirements and procedures. The various forms of waste expected to be encountered during this program are contact waste, purge water, and decontamination wastewater.

Contact waste will be minimized by limiting contact with the sample media and by using disposable materials whenever possible. Contact waste shall be placed into plastic garbage bags and disposed of in a dumpster onsite. If contact waste is determined to be radiologically contaminated, the assigned radiological control technician/engineer shall survey, contain, label, and dispose of the waste according to radiological control requirements.

All decontamination wastewater and purge water will be containerized and disposed of through the Converted Advanced Wastewater Treatment facility (CAWWT) for treatment. The point of entry into the CAWWT will be either the CAWWT backwash basin or the OSDF permanent lift station.

3.6 Safety and Health

Safety and health requirements for the Fernald Preserve are established in accordance with Title 10 *Code of Federal Regulations* Part 851, "Worker Safety and Health Program." This program establishes worker safety and health regulations to govern Legacy Management Support (LMS) contractor activities at U.S. Department of Energy (DOE) sites and establishes the framework for a worker protection program that will reduce or prevent occupational injuries, illness, and accidental losses by requiring DOE contractors to provide their employees with safe and healthful workplaces. These requirements are further defined in LMS contractor procedures, Fernald Preserve standard operating procedures, and job safety analyses.

3.7 Data Management

Information collected as a part of this monitoring program will be managed according to the guidelines below to ensure availability of documentation for verification and reference and to ensure regulatory compliance.

Field documentation, as required by the FPQAPP for this sampling program (e.g., Chain of Custody forms), will be carefully maintained in the field. To ensure that appropriate documentation was completed during field activities and that documentation was completed correctly, required documentation shall be verified by Environmental Monitoring personnel. One hundred percent of the analytical data shall be validated in accordance to the Analytical Support Level (ASL) specified in Tables 1 through 3. Information is stored in the environmental database, and the hard-copy original field documentation packages shall be stored in controlled file storage cabinets and eventually in a long-term archive environment. According to regulatory guidance, these records must be maintained for a minimum of 30 years.

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4.0 References

Note: Tasks associated with this plan are performed under the most current version of plans, procedures, and documents.

APHA (American Public Health Association), 1989. *Standard Methods for Analysis of Water and Wastewater*, 17th Edition.

DOE (U.S. Department of Energy), 2014. *Fernald Preserve Quality Assurance Project Plan*, LMS/FER/S04774, Office of Legacy Management.

DOE (U.S. Department of Energy), 2015. *Fernald Preserve and Mound, Ohio, Sites Environmental Monitoring Procedures*, LMS/FER/MND/S05277, Office of Legacy Management.

EPA (U.S. Environmental Protection Agency), 1983. *Methods for Chemical Analysis of Water and Wastes*, EPA600/4-79-020, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio, March.

EPA (U.S. Environmental Protection Agency), 1998. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, 3rd edition, Office of Solid Waste, Washington, DC, April.

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Appendix C

Fernald Preserve Data Quality Objectives Monitoring Program for the On-Site Disposal Facility

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Contents

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Abbreviations

ASL	Analytical Support Level
BTX	benzene, toluene, and xylenes
CEC	cation exchange capacity
CFR	*Code of Federal Regulations*
DQO	data quality objective
FP EMP	*Fernald Preserve Environmental Monitoring Procedures*
FPQAPP	*Fernald Preserve Quality Assurance Project Plan*
FS	feasibility study
GMA	Great Miami Aquifer
GWLMP	Groundwater/Leak Detection and Leachate Monitoring Plan
HTW	horizontal till well
IEMP	Integrated Environmental Monitoring Plan
LCS	leachate collection system
LDS	leak detection system
OAC	*Ohio Administrative Code*
ORP	oxidation-reduction potential
OSDF	On-Site Disposal Facility
PCBs	polychlorinated biphenyls
PSP	*Project-Specific Plan for the On-Site Disposal Facility Monitoring Program*
QC	quality control
RA	remedial action
RD	remedial design
RI	remedial investigation
RvA	removal action
SVOC	semi-volatile organic compound
SWIFT	Sandia Waste Isolation Flow and Transport
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TOC	total organic carbon
TOX	total organic halogens
TPH	total petroleum hydrocarbons

TSD	treatment, storage, and disposal
VAM3D	Variably Saturated Analysis Model in 3 Dimensions
VOA	volatile organics compounds

1.0 Statement of Problem

Problem Statement: Analytical data, obtained from a multi-component monitoring system, is necessary to support the leak detection element of the On-Site Disposal Facility (OSDF) monitoring strategy.

Construction of the OSDF for long-term storage and containment of low-level radioactive waste was completed in phases with eight individual cells. Each cell is monitored individually for leak detection and possible environmental impact.

A major concern regarding the storage of waste at the Fernald Preserve is the prevention of any additional environmental impact to the Great Miami Aquifer (GMA). To address this concern, site-specific monitoring requirements that integrate state and federal regulatory requirements were developed to provide a comprehensive program for monitoring the ongoing performance and integrity of the OSDF.

In consideration of unique hydrogeologic conditions and preexisting contamination onsite a baseline data set (*Ohio Administrative Code* [OAC] 3745-27-10[D][5][a][ii][a], OAC 3745-27-10[A][2][b], and OAC 3745-54-97[G]) was established. In addition, an alternate sampling program (OAC 3745-2-10[D][5][a][ii][b] and [b][ii][b]; 3745-27-10[D][6]) was initiated to address site-specific complexities and provide an effective monitoring program for the OSDF that meets and exceeds federal and state regulations for treatment, storage, and disposal (TSD) facilities.

The OSDF monitoring program strategy uses OSDF system design in combination with a monitoring well network to provide data for a collective assessment of OSDF performance. Each OSDF cell is constructed with a leachate collection system (LCS) and a leak detection system (LDS); these systems are separate and contain sample collection points within the valve house. The LCS is designed to collect infiltrating rainwater (and storm water runoff during waste placement) and prevent it from entering the underlying environment; the leachate drainage layer drains to the west through an exit point in the liner to a leachate transmission system located on the west side of the OSDF and routed for treatment. The LDS is a drainage layer positioned beneath the primary composite liner; any collected fluids from that layer drain to the west where they are removed and routed for treatment as in the LCS. Flow monitoring of the LCS and LDS will be conducted on a scheduled basis. Monitoring the flow and sampling the LCS and LDS liquids will provide an assessment of migratory dynamics within each cell and determine primary liner performance.

The monitoring well network consists of two separate systems. A horizontal till well (HTW) is placed in the subsurface beneath the LCS and LDS liner-penetration box within each cell. Each liner-penetration box represents the lowest elevational area of each cell, by definition the most likely location for a potential leak to migrate. GMA monitoring wells are placed at the immediate boundaries of each cell, at upgradient and downgradient locations, to monitor the water quality of the aquifer and verify presence or absence of environmental impact.

2.0 Identify the Decision

Flow and analytical data provided by a monitoring program will provide the information necessary for management of the OSDF. Information derived from flow volume assessment and sample analyses will constitute the first tier of a three-tier strategy: detection, assessment, and corrective action; if it is determined from detection monitoring that a leachate leak from the OSDF has occurred, additional groundwater quality assessment studies will be initiated, and corrective action monitoring plans will be developed and implemented as necessary. If the detection monitoring continues to successfully demonstrate that the OSDF is performing as designed, then the monitoring program will remain in the first-tier detection mode, and a follow-up groundwater quality assessment or corrective action monitoring plans will not be necessary.

The OSDF monitoring strategy includes the establishment of baseline conditions in the hydrogeological environment beneath each cell prior to waste placement. Both perched groundwater and the GMA contain uranium and other Fernald Preserve-related constituents at levels above background near the OSDF; therefore, it is necessary to establish preexisting conditions (constituent concentration levels and variability) for applicable OSDF monitoring parameters.

3.0 Inputs That Affect the Decision

An extensive characterization of wastes to quantify environmental contamination in the area of the Fernald Preserve provided the information to develop the waste acceptance criteria for waste entering the OSDF. The leachability, mobility, persistence, toxicity, and stability of identified waste constituents were evaluated, and of 93 constituents, less than 20 constituents were identified as having the potential to impact the aquifer within a 1,000-year performance period. These site-specific leak detection indicator parameters chosen as monitoring parameters will be supplemented with additional water chemistry indicator parameters.

Additionally, waste TSD facilities must analyze collected leachate annually to fulfill a reporting requirement according to Ohio Solid Waste regulation OAC 3745-27-19(M)(5). Through 2008, OSDF monitoring was complying by collecting a grab sample yearly and performing analysis for the parameters listed in Appendix I of OAC 3745-27-10 and polychlorinated biphenyls (PCBs). Waste is no longer being placed in the OSDF, an alternate sampling constituent list has been approved for the OSDF, a common-ion study has been completed, and additional Appendix I parameters have been identified for Cells 1 through 8. Annual sampling in the LCS focuses on site-specific parameters that have been approved for the facility, common-ion parameters identified in the common-ion study as being beneficial monitoring parameters and additional Appendix I parameters identified for Cells 1 through 8.

Monitoring of the liquid flow within the LCS and LDS drainage layers will be performed to provide a trend analysis that can be used as an indicator of containment system performance; changes in the trend of flow will initiate follow-up inspection and corrective action measures as necessary. A graded approach, patterned after federal hazardous waste landfill regulations in Title 40 *Code of Federal Regulations* (CFR) Part 264.303(c)(2) and Ohio solid waste rule OAC 3745-27-19(M)(4), will be used to provide a quantitative monitoring control for drainage within the OSDF.

4.0 Define the Boundaries of the Study

Subsurface conditions in the immediate area of the OSDF consist of a glacial till underlain by sand and gravel deposits that constitute the GMA. The GMA is a high-yield aquifer and a designated sole-source aquifer under the Safe Drinking Water Act. It supplies a significant amount of potable water for private and industrial use in Butler and Hamilton Counties, Ohio; therefore, a leakage of contaminants from the OSDF could affect water quality for a large population.

Typically, a detection monitoring program consists of upgradient and downgradient monitoring wells with routine sampling for a prescribed list of parameters. Consequently, detection of a statistically significant difference in downgradient water quality indicates that a release from a facility may have occurred. However, at the Fernald Preserve, low permeability and preexisting contamination within the overburden, and implementation of a sitewide groundwater remedial action (RA) for the subsurface, add complexity to the development of a groundwater detection monitoring program that is consistent with the standard approach in solid and hazardous waste regulations. To accommodate such complexities, federal and state regulations allow alternative monitoring strategies, which provide flexibility with respect to well placement, statistical evaluation of data, parameter lists, and sampling frequency. The OSDF monitoring program incorporates an appropriate alternative monitoring strategy to ensure integrity and provide effective early warning of a leak from the facility. The program includes alternate well placement, statistical analysis, parameter lists, and sampling frequencies.

An OSDF leak would migrate vertically downward toward the GMA; therefore, a horizontally positioned well placed within the glacial till shall have its screened interval beneath the LCS and LDS liner-penetration box of each cell as a site-specific approach to monitor a first-entry leakage from the OSDF. The GMA wells are installed immediately adjacent to the OSDF, just outside the boundary of the final composite cap. Each cell is monitored with a set of GMA monitoring wells, placed upgradient and downgradient of each cell. A network of GMA monitoring wells borders the OSDF and provides upgradient and downgradient monitoring points for the entire facility.

The parameters are limited to those indicated as having a potential to migrate from the OSDF and impact the GMA. The concentration levels of concern are those required to determine fluctuations in GMA concentrations and provide a sensitivity great enough to indicate potential impacts.

Sampling frequencies for the OSDF monitoring program meet federal and state requirements. The additional data will be used to develop an appropriate statistical procedure and to compensate for the varying temporal conditions in the groundwater flow direction and chemistry due to seasonal fluctuations.

5.0 Decision Rule

Both water quality and leachate flow rates will be evaluated to determine the potential that a leak from a cell might be occurring. The U.S. Department of Energy will first review and compare flow rates from the LDS to the design action leakage rate to determine if sufficient hydraulic head is present in a cell to drive leachate through a liner breach. The key to a plausible potential-leak determination is the presence of an adequate hydraulic head (i.e., action leakage rate is present) coupled with observed water quality changes in the LDS and HTW. The water quality of the monitored horizon will also be used to assess for potential leakage. Unless an upward concentration trend in an HTW or GMA well is accompanied by a corresponding action leakage flow rate in the LDS, the upward concentration trend will not be attributed to a potential leak from the OSDF.

Three water quality data interpretation techniques will be used to assess changing water quality conditions in HTW and GMA wells and compare conditions in the HTW and GMA wells to conditions inside the facility in the LCS and LDS. Concentrations will be trended over time for those constituents that have not reached steady-state conditions. Control charts will be prepared for those constituents that are stable. Bivariate plots will be prepared for each cell to illustrate how the water quality signature of the LCS, LDS, and HTW of a cell compare.

Data collected from the OSDF monitoring program will also be used to supplement the compilation of data for the Integrated Environmental Monitoring Plan (IEMP) reports (Attachment D). Groundwater data for those OSDF leak detection constituents that are also common to the IEMP groundwater remedy performance constituents will be used in the IEMP data interpretations as the data become available. Groundwater data collected for the unique OSDF leak detection constituents that are not being monitored by the IEMP groundwater monitoring program will be used only for the establishment of the OSDF baseline and subsequent leak detection monitoring. To provide an integrated approach to reporting OSDF monitoring data, the annual Site Environmental Report will serve as the mechanism by which LCS and LDS volumes and concentrations will be reported, along with groundwater monitoring results, trending results, and interpretation of the data. Presenting data in one report will facilitate a qualitative assessment of the impact of the OSDF on the aquifer, as well as the operational characteristics of OSDF caps and liners.

6.0 Limits on Uncertainty

The sensitivity and precision must be sufficient to define the GMA concentrations of the parameters of concern such that fluctuations will be observable, and effects impacting the final remediation levels are observed. A false-positive error would indicate either that certain parameters are present when in fact they are not, or that baseline parameters are present at higher concentrations than are actually present in the GMA. This type of error would give a false indication that a leak may exist. A false-negative error would indicate that certain parameters are not present when in fact they are. This may lead to a mistaken indication that a leak is not occurring. It is necessary to define the concentrations of the parameters of concern such that fluctuations in concentration and effects impacting the GMA will be observable.

7.0 Optimize Design

An aquifer simulation model (i.e., Sandia Waste Isolation Flow and Transport [SWIFT] and, more recently, Variably Saturated Analysis Model in 3 Dimensions [VAM3D]) was used to select monitoring well locations, typically one upgradient and one downgradient of each cell. These wells are used in the detection monitoring program, as well as for baseline establishment.

Standard statistical modeling studies indicate that data from a minimum of four independent sampling events are necessary to establish baseline values; however, for an improved comparative statistical analysis, more sampling events were chosen to ensure sufficient available data for baseline establishment for each GMA monitoring well location.

To ensure consistency of method and an auditable sampling process, each sample will be collected according to the following:

- *Fernald Preserve and Mound, Ohio, Sites Environmental Monitoring Procedures* (DOE 2015).
- *Fernald Preserve Quality Assurance Project Plan* (FPQAPP) (DOE 2014).
- Project-Specific Plan for the On-Site Disposal Facility Monitoring Program (PSP) (Attachment C, Appendix B).

Laboratory quality control (QC) requirements will be as specified in the FPQAPP and PSP. One hundred percent of the data will undergo field and laboratory validation.

All chemical sample analyses will be performed at Analytical Support Level (ASL) D, except field water quality analyses, which will always be performed at ASL A. Radiological constituents will be analyzed at ASL D.

All samples require field QC and will include trip blanks as specified in the FPQAPP. Duplicates will be collected for each sampling round (a "sampling round" is defined as one round of sample collection from various locations occurring within a short period of time [i.e., several days]). Equipment rinsate blanks will be collected when dedicated equipment is not available. One laboratory QC sample set shall be collected per each release of samples. Laboratory QC will include a method blank and a matrix spike for each analysis, as well as all other QC required according to the method and FPQAPP.

If a well does not recharge sufficiently to allow collection of specified volumes for all analytes, or the LCS/LDS systems do not contain sufficient volume for a full suite of samples, parameters will be collected in the order of priority stated in the PSP. Sampling parameter requirements and frequencies are defined in the PSP and meet applicable federal and state requirements.

8.0 Data Quality Objectives

Baseline Establishment for GMA Groundwater Monitoring of the OSDF

1a. Task/Description. Baseline Establishment for GMA Groundwater Monitoring of the OSDF. This sampling program will determine a baseline characterization of the GMA in the immediate vicinity of the OSDF.

1b. Project Phase. Put an *X* in the appropriate box:

RI ☐ FS ☐ RD ☐ RA ☐ R_VA ☐ Other ☒ Specify: Post-Closure______

1c. DQO No.: GW-024____ DQO Reference No.: not applicable

---

2. Media Characterization. Put an *X* in the appropriate box:

Air ☐ Biological ☐ Groundwater ☒ Sediment ☐ Soil ☐

Waste ☐ Wastewater ☐ Surface water ☐ Other ☐ Specify: Leachate_____________

---

3. Data Use with ASLs A−E. Put an *X* in the appropriate ASL boxes beside each applicable data use:

Site Characterization
A ☐ B ☐ C ☐ D ☐ E ☐

Risk Assessment
A ☐ B ☐ C ☐ D ☐ E ☐

Evaluation of Alternatives
A ☐ B ☐ C ☐ D ☐ E ☐

Engineering Design
A ☐ B ☐ C ☐ D ☐ E ☐

Monitoring during remediation activities
A ☐ B ☐ C ☐ D ☐ E ☐

Other (specify):_Post-Closure________
A ☒ B ☐ C ☐ D ☒ E ☐

4a. Drivers. OSDF GWLMP, the OAC for the containment of solid and hazardous waste, and the CFR TSD Facility Standards.

4b. Objective. To provide information by which verification of the ongoing performance and integrity of the OSDF and its impact on groundwater can be evaluated.

5. Site Information (description). The OSDF will consist of eight individual cells, and each cell will be monitored on an individual basis. The monitoring system developed to detect any potential leaks originating from the cells consists of four components: an LDS, an LCS, a till monitoring system, and a Great Miami Aquifer monitoring system. This DQO addresses post-closure OSDF leak detection monitoring.

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6. Data Types with Appropriate ASL. Put an *X* in the appropriate boxes for required analyses:

A. pH	☒	B. Uranium	☐	C. BTX	☐
Temperature	☒	Full Radiologic	☒*	TPH	☐
Specific Conductance	☒	Metals	☒*	Oil/Grease	☐
Dissolved Oxygen	☒	Cyanide	☐		
Turbidity	☒	Silica	☐		

D. Cations	☐	E. VOC	☒*	F. Other (specify): Total Alkalinity, Ammonia, Chloride, TDS, Sulfate, Nitrate/Nitrite, Fluoride, ORP
Anions	☐	SVOC	☒*	
TOC	☒	Pesticides	☒*	
TCLP	☐	PCB	☒	
CEC	☐	TOX	☒	
COD	☐			

*See specific parameters listed in PSP.

7a. Sampling Methods. Put an *X* in the appropriate box:

Biased ☐ Composite ☐ Environmental ☐ Grab ☒ Grid ☐

Intrusive ☐ Non-Intrusive ☐ Phased ☐ Source ☐

Other (specify): ______ DQO Number: DQO #GW-024

7b. Sample Work Plan Reference. List the samples required and reference the work plan or sampling plan guiding the sampling activity, as appropriate. Baseline/background samples and routine monitoring samples: PSP for onsite disposal monitoring program.

7c. Sample Collection Reference. Provide a specific reference to the FPQAPP section and subsection guiding sampling collection procedures. A PSP will detail sampling methodology; unless otherwise indicated in the PSP, sampling will follow requirements outlined in the FPQAPP and FP EMP.

Sample Collection Reference: FPQAPP and FP EMP.

---

8. Quality Control Samples. Put an *X* in the appropriate box:

Field Quality Control Samples

Trip Blanks	☒	Container Blanks	☐
Field Blanks	☐	Duplicate Samples	☒
Equipment Rinsate Samples	☒	Split Samples	☐
Preservative Blanks	☐	Performance Evaluation Samples	☐

Other (specify): none required

Laboratory Quality Control Samples

Method Blank	☒	Matrix Duplicate/Replicate	☒
Matrix Spike	☒	Surrogate Spikes	☒

Other (specify) none required

---

9. Other. Provide any other germane information that may impact the data quality or gathering of this particular objective, task, or data use.

9.0 References

DOE (U.S. Department of Energy), 2014. *Fernald Preserve Quality Assurance Project Plan,* LMS/FER/S04774, Office of Legacy Management.

DOE (U.S. Department of Energy), 2015. *Fernald Preserve and Mound, Ohio, Sites Environmental Monitoring Procedures,* LMS/FER/MND/S05277, Office of Legacy Management.

Appendix D

Leachate Management System for the On-Site Disposal Facility

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Contents

Figure

Tables

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Abbreviations

CAWWT	Converted Advanced Wastewater Treatment Facility
CFR	*Code of Federal Regulations*
cm	centimeter
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
EPLTS	enhanced permanent leachate transmission system
ft	foot/feet
HDPE	high-density polyethylene
HMI	Human–Machine Interface
LCS	leachate collection system
LDS	leak detection system
LTS	leachate transmission system
OAC	*Ohio Administrative Code*
OSDF	On-Site Disposal Facility
PLS	permanent lift station
PS	pipe segment
RLCS	redundant leachate collection system

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1.0 Overview

The double liner system of each On-Site Disposal Facility (OSDF) cell contains a leachate collection system (LCS) and a leak detection system (LDS). These systems are designed to convey any leachate/fluid that enters the system through pipes (i.e., the LCS pipes and LDS pipes) to valve houses located outside each cell. After closure of the OSDF, fluids that enter the LCS have infiltrated through the emplaced impacted material. Fluid that collects in the LCS and LDS collection tanks located in the valve house for each cell will be pumped to the enhanced permanent leachate transmission system (EPLTS). The EPLTS conveys leachate from each of the valve houses, via gravity flow, to a permanent lift station (PLS). The location of the LCS, LDS, and EPLTS pipes and gravity lines are shown in the as-built construction drawings.

The *Systems Plan, On-site Disposal Facility* (DOE 2000), and *Systems Plan, Collection and Management of Leachate for the On-site Disposal Facility* procedure (DOE 2001a) provide specifics on activities during post-closure monitoring. Note that operational procedures are included in the *Wastewater Treatment Outside Systems Procedure for the Fernald Preserve, Fernald, Ohio* (DOE 2015b) and the *Converted Advanced Wastewater Treatment Facility Procedure for the Fernald Preserve, Fernald, Ohio* (DOE 2015a). Equipment will be maintained, operated, and serviced according to manufacturer instructions and Section 4 of the *Wastewater Treatment Outside Systems Procedure for the Fernald Preserve, Fernald, Ohio* (DOE 2015b).

2.0 Basic System Operation

What follows is a description of the basic operation of the OSDF leachate management system.

- The LCS and LDS pipes from the liner system to the valve houses for each cell consist of double-wall, high-density polyethylene (HDPE) pipes (i.e., inner carrier pipes and outer containment pipes). Each pipe drains by gravity from below the OSDF cell and terminates in a valve house for each cell.
- The LDS line in each valve house allows for direct discharge of flow from the LDS carrier pipe into a collection tank located inside the valve house. The lined valve house foundation wall serves as a secondary containment structure for the collection tank. The valve house has provisions to monitor liquid in the collection tank. The tank is equipped with a level-sensing element and a pump to discharge the contents of the tank. The tank level is monitored by the Converted Advanced Wastewater Treatment Facility (CAWWT) Human-Machine Interface (HMI), and the tank is pumped automatically when the level reaches 80 percent. The discharge pipe from the tank pump is connected to the EPLTS gravity line. The LDS containment pipe has a monitoring port and a fixed end seal within the valve house to verify the absence of fluid in the annular space between the carrier pipe and containment pipe.
- Each LDS line has a cleanout within the valve house for maintaining the LDS carrier pipe.
- The LCS allows direct discharge of flow from the LCS carrier pipe into the EPLTS gravity line that passes through each valve house. LCS flow has diminished to the point that flow from all eight cells is currently directed through the collection tanks in each valve house. The tank level is monitored by the CAWWT HMI, and the tank is pumped automatically when the level reaches 80 percent. The LCS carrier pipe in each valve house also has a

sampling port for obtaining leachate samples. Each valve house has an inlet for a redundant LCS (RLCS) carrier pipe. The redundant carrier pipe has a valve (secured in a closed position) and a monitoring port (for periodically confirming the absence of leachate in the pipe). The redundant carrier pipe valve is configured so that it can be opened to allow flow to the LCS tanks and then to the EPLTS gravity line in the event of a failure due to clogging of the primary LCS carrier pipe. Both the primary and RLCS containment pipes have monitoring ports and fixed end seals within the LCS to verify the absence of leachate in the annular space between the carrier pipe and the containment pipe.

- Each valve house is equipped with liquid-level alarms, consisting of a submersible liquid-level sensor (located in a small sump in the corner of each valve house) and alarm light. The liquid-level sensor is calibrated so that the alarm is activated when the fluid level in the valve house sump reaches approximately 11 inches.
- The EPLTS gravity line consists of a double-wall HDPE pipe with a 6-inch (15.2-centimeter [cm])-diameter inner carrier pipe, and a 10-inch (25-cm)-diameter outer containment pipe.
- The EPLTS gravity line is equipped with a vent at its northern end. The purpose of the vent is to prevent pressure buildup in the systems. The EPLTS gravity line has cleanouts in each valve house that provide access to the EPLTS line in both directions for maintenance.
- The PLS has secondary containment designed so that it can be monitored for the presence of leakage.
- The PLS was designed to be capable of storing the anticipated quantity of leachate generated during a 1-week period using design assumptions simulating final closure of the OSDF.
- Prior to the discharge of fluid into the PLS, the fluid passes through a motor-operated inflow valve located in the control valve house just upstream of the PLS. This valve closes automatically in the event of a power failure, or if fluid levels in the lift station rise above the high-level alarm set point (or any level that would cause an electrical short or damage to equipment in the lift station). In the event of a power failure or high-level alarm, the motor-operated valve for the leachate transmission system (LTS) will close automatically. Therefore, this valve can be closed if needed until appropriate maintenance activities can be implemented.
- The PLS is equipped with a pumping system to transfer liquids in the lift station to the CAWWT for treatment.

2.1 LDS and LCS

The LDS and LCS of each OSDF cell shall be operated in conformance with the requirements of Section 4 of the *Wastewater Treatment Outside Systems Procedure for the Fernald Preserve, Fernald, Ohio* (DOE 2015b).

The valve on the RLCS carrier pipe shall be maintained closed at all times, unless it is determined that the LCS pipe is clogged.

In order to allow discharge to the EPLTS gravity line, the valve on the LCS carrier pipe shall be maintained open at all times during the post-closure period of the OSDF, except for those periods when the valve needs to be closed for system maintenance and repair, or in the event of an operational emergency.

The LCS valve houses are designed as a closed system; leachate should not accumulate in these valve houses. The sumps in the valve houses will be pumped as needed when water in the sump reaches the alarm level.

3.0 Inspection and Maintenance Activities

The *Wastewater Treatment Outside Systems Procedure for the Fernald Preserve, Fernald, Ohio* (DOE 2015b) provides the current details associated with inspection and maintenance activities for the leachate management system. The following subsection and Table 1 provide guidelines for the activities to continue during the post-closure period.

3.1 LCS and LDS

The LCS and LDS shall be inspected and maintained according to the schedule and activity requirements outlined in Table 1, or until leachate is no longer generated and an alternative activity schedule has been approved.

According to appropriate regulations—*Ohio Administrative Code* (OAC) 3745-27-19(k)(3)—the routine inspection of the pipe network shall be annual until final closure to ensure that clogging has not occurred. Clogging could occur from deposition of sediments or from biological growth inside the pipe. Since the facility closed in 2006, the annual inspection requirement is no longer applicable. The U.S. Department of Energy (DOE) inspected the pipe network in 2010. When inspections occur, this pipe network shall be inspected between the valve house and the first 100 feet (ft) of the subdrain pipe inside the cell (at a minimum). The portion of the pipe beyond this point inside the cell is considered redundant because gradation for the LCS granular drainage material is designed to limit the level of leachate on the geomembrane liner to less than 1 ft (0.3 meter) without need for a subdrain pipe.

Access to the network pipes for inspection shall be through cleanouts located in each cell's valve house. Inspections shall be performed using a video camera, or any other appropriate inspection equipment. The inspection equipment shall have the ability to monitor its location (e.g., distance counter), be sized to fit within the LCS and LDS inner carrier pipes indicated on construction drawings, and be capable of being pushed the length to be inspected.

If an inspection indicates that a pipe in the pipe network is obstructed, the pipe shall be flushed by pumping water from a water truck through a hose inserted in the pipe cleanout. If flushing does not remove the obstruction, other methods shall be used to clean the pipe. These other methods may include blowing the obstruction out with air; vacuuming; jet rodding; or inserting a snake, fish tape, or other suitable device. If air or water pressure is used, the working pressure inside the pipe shall not exceed the rated pressure for the pipe.

Table 1. Post-Closure OSDF Leachate Management System Inspection and Maintenance Activities

Component	Inspection Frequency	Conditions to Check	Remedy (and/or Actions)
Routine inspection and maintenance of LDS	Various	• Check general condition of valve house for each cell annually. • Inspect the primary containment vessel for leakage quarterly. • Check for fluid in LDS containment pipe monthly.	• Check level transmitter operations (e.g., operating temperature range, accuracy), electrical connections, and alarm light. • Check for source of leak; if source identified, then take appropriate corrective measures (e.g., spot-seal vessel, replace vessel). • Keep monitoring port drained; if above the action level in the *Leachate Management Contingency Plan for the On-Site Disposal Facility* (DOE 2001b), perform video inspection of pipe and attempt to identify source of leakage; develop plan to mitigate effects.
Routine inspection and maintenance of LCS	Various	• Check general condition of valve house for each cell annually. • Check for leachate in LCS containment pipe monthly.	• Check level transmitter operations (e.g., operating temperature range, accuracy), electrical connections, and radio transmission. • Keep monitoring port drained; if above the action level specified in the *Leachate Management Contingency Plan for the On-Site Disposal Facility* (DOE 2001b), perform video inspection of pipe and attempt to identify source of leakage; develop plan to mitigate effects.
Routine inspection and maintenance of pipe networks	Once every 5 years if needed. Note: Monitoring is anticipated to remain in effect until it is demonstrated that leachate no longer poses a threat to human health or the environment. Temporary suspension of leachate requirements may also be considered.	• Check condition of shutoff valve. • Check for leachate in LCS containment pipe monthly. Video inspect for: • Cracking/crushing of pipe. • Clogging of pipe.	• Check valve operability; correct any deficiencies. • Drain pipe into EPLTS gravity line. • Flush clogged pipe with water or mechanically clean. • Insert small-diameter pipe in crushed pipe, if possible. • Replace cracked/crushed pipe if cracked/crushed portion is outside of the cell. • Use RLCS.

Table 1 (continued). Post-Closure OSDF Leachate Management System Inspection and Maintenance Activities

Component	Inspection Frequency	Conditions to Check	Remedy (and/or Actions)
OSDF cell valve houses	Annually	• Confirm that all required signage is visible.	• Repair or replace as necessary.
		• Check general structural condition of valve house components.	• Check for structural integrity; if problems are found, take appropriate measures (e.g., spot-seal vessel, replace vessel) and implement permanent solution.
		• Check for odors, bacterial growth (containment vessel).	• Clean tanks when needed with Alconox or equivalent.
EPLTS gravity line	Various	• Check for fluid in EPLTS gravity line containment pipe monthly.	• Keep containment pipe drained; if above the action level specified in the *Leachate Management Contingency Plan for the On-Site Disposal Facility* (DOE 2001b), perform video inspection of pipe and attempt to identify source of leakage; if leakage is minor, continue to operate; if leakage is significant, evaluate repair options.
		• Inspect pipe for clogging or crushing once every 5 years if needed.	• Flush clogged pipe with water, or mechanically clean; repair as necessary.
LCS and LDS tank-level transmitters	Once every 6 months	• Operational check of transmitter.	• Clean or replace as necessary.
Valve house sump alarms	Quarterly	• Verify that the alarm switch is operational. • Verify that the alarm signal is sent to and acknowledged at the alarm panel in the valve house.	• Repair or replace switch and/or panel relay as necessary.

The specific pipe maintenance procedures (other than flushing) to be used to remove a pipe obstruction will be selected by DOE on a case-by-case basis.

If an LCS or LDS pipe obstruction cannot be dislodged, or in the very unlikely event that a pipe has undergone partial or total cracking, the following procedures will be considered:

- For the LCS, activate the RLCS pipe.
- For the LCS or LDS, insert a new small-diameter pipe within the obstructed/collapsed pipe or replace the broken piece, as necessary.
- For the LCS or LDS pipe, if the obstruction or collapse is outside of the disposal facility containment systems, replace the pipe.
- All equipment inserted into the LCS or LDS line for inspection and/or maintenance shall be decontaminated prior to its removal from the OSDF.

In addition to the aforementioned requirements, all mechanical and electrical equipment shall be tested, operated, maintained, and serviced according to the manufacturer’s instructions and site procedures.

3.2 EPLTS Inspection and Maintenance Activities

The EPLTS shall be inspected and maintained in accordance with the schedule and activity requirements outlined in Table 1, or until leachate is no longer generated and an alternative activity schedule has been approved.

The LTS, valves, connections, sampling ports, monitoring ports, pumps, and other components shall be routinely inspected and maintained to provide for proper OSDF operation. All mechanical and electrical equipment shall be tested, operated, maintained, and serviced according to the manufacturers’ instructions and site procedures.

In addition, the inspection and maintenance activities for the EPLTS shall include the following:

- Confirm that appropriate warning signs are visible (e.g., for confined space).
- Check instruments and valves (e.g., note any sticking or jammed devices, corrosion, leaks, and misalignments).
- Verify instrument systems status (e.g., operation of automatic level switch in the lift station).
- Check for the presence of fluids in all secondary containment systems.
- Confirm pump operation.

4.0 Leachate Management

Treatment of fluids collected from the LCS and LDS will be through the CAWWT as long as it is operating. Long-term treatment of the fluids collected from the LCS and LDS will be evaluated prior to discontinuation of operations of the CAWWT. In accordance with Ohio solid waste rule OAC 3745-27-19(K)(5), some of those alternatives are expected to consist of the following:

- Onsite pretreatment of collected fluids with offsite disposal.
- Offsite treatment and disposal of collected fluids.
- Various options that may exist for the offsite portion of either of these alternatives.

Offsite treatment and/or disposal would likely require collection of leachate in the sump or another accumulation tank while awaiting periodic removal. Any modification involving such accumulation in a tank would require an estimate of the quantity of leachate per time period, in order to specify the frequency of removal and how it will be disposed of or treated.

The processes presented above are expected to remain in effect until leachate is no longer detected (refer to federal hazardous waste regulation in Title 40 *Code of Federal Regulations* [CFR] Part 264.310[b][2]), or until it is demonstrated that leachate no longer poses a threat to human health or the environment. If leachate volumes decrease below anticipated levels and the leachate toxicity decreases, DOE may choose to petition the director of the Ohio Environmental Protection Agency (Ohio EPA) to modify or temporarily suspend some of the leachate management requirements. OAC 3745-66-18(G) gives the director of Ohio EPA authority to extend or reduce the post-closure care period based on cause. Eventually the leachate management system will be placed into its final, long-term configuration with the valve houses and contents being removed and replaced with straight lengths of pipes connecting the LDS and LCS to the EPLTS line. The decision regarding when the long-term configuration can be implemented will be made with concurrence of the U.S. Environmental Protection Agency (EPA) and Ohio EPA. This decision will be based on criteria developed in consultation with EPA and Ohio EPA. The criteria will include factors such as asymptotic leachate flows, a past history of no problems with plugging of the LCS or LDS lines, no recent activity to repair or revegetate the cap, and the absence of similar conditions that would argue for maintaining the ability to inspect and repair the LCS and LDS lines.

Information associated with leachate monitoring will be reported through the annual Site Environmental Reports as identified in the front sections of the OSDF Groundwater/Leak Detection and Leachate Monitoring Plan (Attachment C of the Legacy Management and Institutional Controls Plan).

5.0 Leachate Contingency Plan

By the summer of 2006, the flows from the OSDF LCS and LDS had decreased significantly due to the filling and capping of cells. The previous *Leachate Management Contingency Plan for the On-Site Disposal Facility* (DOE 2001b) was written in January 2001 for failure of the LDS, LCS, or EPLTS lines. The plan contained detailed operating modes for each line failure, including failure of the line downstream of the PLS that required using a tanker to transport water from the PLS to the treatment system. A review of the plan indicated that most of the actions detailed in the plan are no longer applicable. For a failure of the EPLTS or the line downstream of the PLS, the preferred option is to close the valves from the LDS and LCS for each cell, allow the water to accumulate in the cells, and repair the line as necessary.

To determine if this option was feasible, calculations were performed for each cell to determine how much water could be allowed to accumulate in each cell without exceeding 1 ft of head on the primary liner (DOE 1997). Information from GeoSyntec indicated that the 1-ft level would be reached in each cell when 8,623 gallons had accumulated (GeoSyntec 2006). Daily flow from the cells in September of 2007 was compared to that volume to determine the number of days required for each cell to accumulate 8,623 gallons. Table 2 shows the data used to determine the number of days.

Table 2. Determination of the Number of Days Required to Reach the 1-ft Level (8,623 Gallons)

Tank	Dates	Water Volume (gallons)	Change in Time (days)	Gallons per Day	Gallons per Acre per Day	Days to Accumulate 8,623 Gallons
LCS 1	9/12–9/19	411	7.00	58.7	9.17	146
LCS 2	9/13–9/15	157.45	1.96	80.4	12.56	107
LCS 3	9/13–9/15	136.84	1.92	71.4	11.16	120
LCS 4	9/13–9/15	216.04	1.96	110.3	17.24	78
LCS 5	9/14–9/16	224.04	1.92	116.9	18.26	73
LCS 6	9/14–9/16	159.41	1.96	81.4	12.72	105
LCS 7	9/14–9/17	192.77	3.00	64.3	10.04	134
LCS 8	9/13–9/15	208.82	1.92	108.9	11.71	79

Since the minimum number of days required to reach the accumulation limit was determined to be 73, and the number of days needed has increased since 2007 as the flow from the individual cells have continued to decrease, transporting leachate water by tanker to the treatment system in the event of a line failure continues to remain unnecessary. If any of the lines in the leachate system fail, the valves from the affected cell's LDS and LCS will be closed, and water will be allowed to accumulate in the cells while repairs are performed. The new contingency leachate plan for the EPLTS or the line downstream of the PLS is to develop a repair plan and repair the line(s) before any of the affected cells accumulate 8,623 gallons. If repairs are anticipated to take longer than the time it would take to accumulate 1 ft of head on the primary liner, leachate would be transferred to the CAWWT via a rental tanker truck or other portable tank.

Monitoring of the LDS, LCS, RLCS, and LTS containment pipes will continue as specified in Table 1. Refer to Figure 1 for a schematic of the Leachate Management System. The actions levels listed in Table 3 were derived from the *Leachate Management Contingency Plan for the On-Site Disposal Facility* (DOE 2001b) and apply on a weekly basis. As the period between monitoring events is extended, the weekly action levels will be multiplied by the number of weeks between monitoring events to yield the applicable periodic action levels.

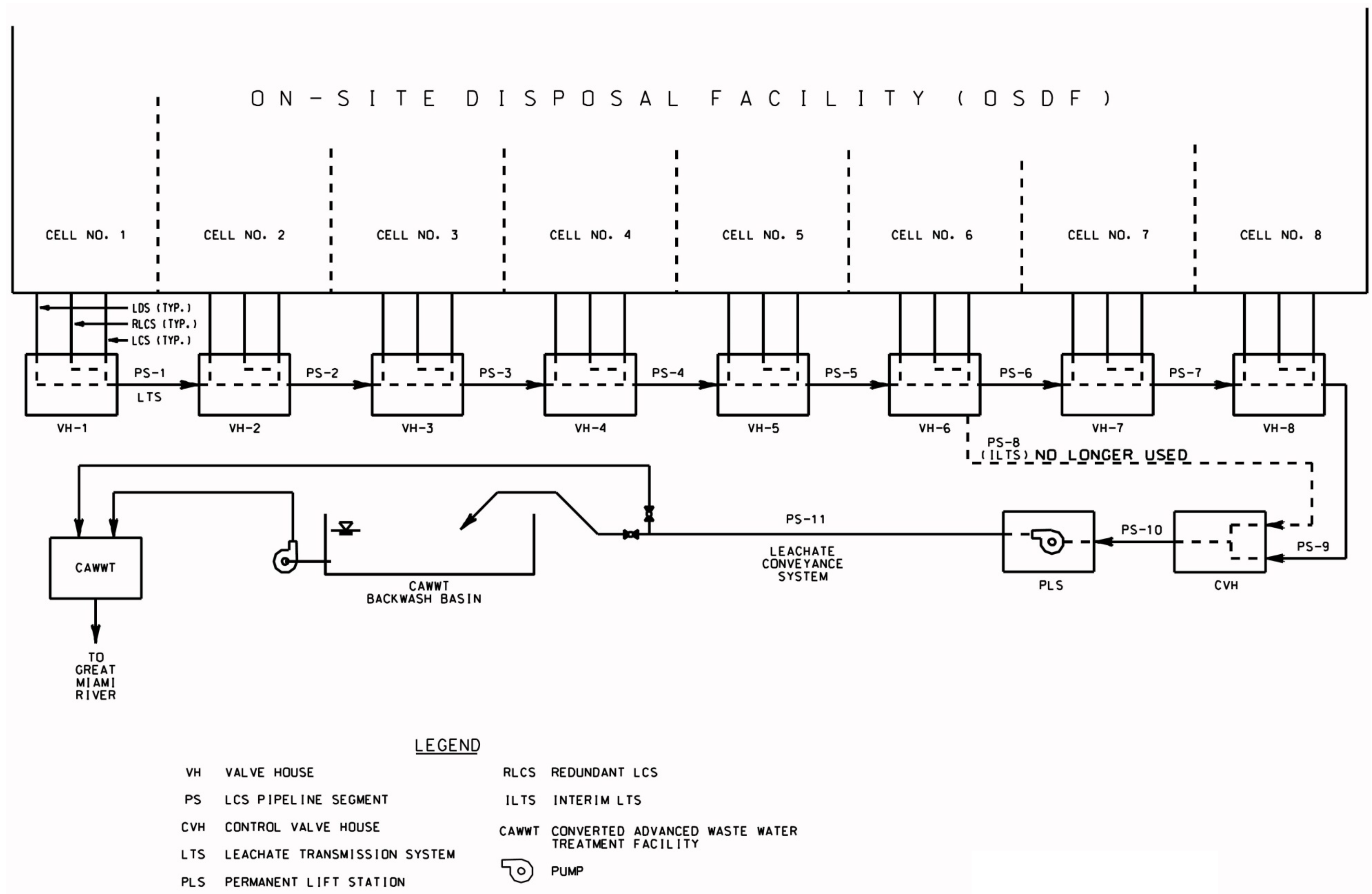

Figure 1. Leachate Management System

Table 3. Action Levels for Containment Pipe Monitoring

	LDS	LCS	RLCS	LTS in Each Valve House (PS-1 through PS-7)	LTS at Port V1007 (PS-9)	LTS at Port V1006 (PS-10)
Weekly Maximum (milliliters)	2,270	2,650	2,650	5,300	18,900	370

If the water collected from any monitoring port exceeds the action level for the period, the port will be checked again in 1 week. If the amount of water collected again exceeds the action level, an investigation of the pipe segment (PS) in question will be performed and corrective actions taken as needed. Note that PS-8 on Figure 1 is no longer monitored because the interim LTS is no longer used as a contingency pipeline.

6.0 References

40 CFR 264. U.S. Environmental Protection Agency, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Section 310, "Closure and Post-Closure Care," *Code of Federal Regulations*, July 1, 2008.

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DOE (U.S. Department of Energy), 2015b. *Wastewater Treatment Outside Systems Procedure for the Fernald Preserve, Fernald, Ohio*, LMS/FER/S02765, Office of Legacy Management.

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Appendix E

Selection Process for Site-Specific Leak Detection Indicator Parameters

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Contents

Figures

Tables

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Abbreviations

COC	constituent of concern
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FS	feasibility study
GMA	Great Miami Aquifer
HTW	horizontal till well
LCS	leachate collection system
LDS	leak detection system
mg/kg	milligrams per kilogram
OAC	*Ohio Administrative Code*
OSDF	On-Site Disposal Facility
OU	Operable Unit
PCB	polychlorinated biphenyls
pCi/g	picocuries per gram
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
TDS	total dissolved solids
TOC	total organic carbon
TOX	total organic halogens
WAC	waste acceptance criteria

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1.0 Introduction

A successful leak detection monitoring program must focus on the best indicators of potential releases, as opposed to analyzing for every possible constituent that may be present in a disposal facility (which would add unnecessary complexity to the data analysis process). This section presents the criteria and process used to identify the site-specific indicator parameters for the On-Site Disposal Facility (OSDF) groundwater leak detection monitoring program.

2.0 Guidelines for Site-Specific Monitoring Parameter Selection

At the Fernald Preserve, residual soil contamination may impact the aquifer at concentrations below the groundwater final remediation levels but statistically elevated above current background conditions. All of the inorganic constituents and all but nine organic constituents included in the regulatory default monitoring parameters list (i.e., Appendix I of *Ohio Administrative Code* [OAC] 3745-27-10) have been detected in perched groundwater samples collected at various locations under the Fernald Preserve. Such preexisting contamination in the environment beneath the site, along with aquifer remediation activities, add complexity to the development of a successful leak detection parameter list capable of indicating the presence of a leak from the OSDF. Therefore, a tailored leak detection parameter list has been developed that provides adequate leak detection and is in compliance with the standard requirements of the Ohio Solid Waste Rules and the Ohio Hazardous Waste Rules. As discussed in Section 3.0 of the Groundwater/Leak Detection and Leachate Monitoring Plan (Attachment C), both sets of rules allow the use of an alternate monitoring parameter list based on site-specific conditions.

Ohio Solid Waste regulations OAC 3745-27-10(D)(2) and (3) allow six considerations in proposing an alternate monitoring parameter list in lieu of some or all of the parameters listed in Appendix I of OAC 3745-27-10. Also, the Ohio Hazardous Waste regulations for new facilities, OAC 3745-54-98(A), recognize four considerations in formulating the facility-specific monitoring parameter list. Table 1 summarizes the important considerations and approval criteria related to monitoring parameter selection under the Ohio Solid Waste and Ohio Hazardous Waste regulations.

The chemical constituents listed in Appendix I of OAC 3745-27-10 are typical contaminants found in sanitary landfills. Appendix I does not include any radionuclides, which are the primary constituents of concern (COCs) at the Fernald Preserve. Therefore, any site-specific constituents that are not included in Appendix I of OAC 3745-27-10, but that are good indicators of potential leaks from the OSDF, also need to be evaluated in the parameter selection process. However, the general considerations summarized in Table 1 can apply to any constituent when selecting the leak detection indicator parameters.

Table 1. Regulatory Criteria for Alternate Parameter List

Ohio Solid Waste Regulation	Ohio Hazardous Waste Regulation
Requirements:	
• For all parameters, the removed parameters are not reasonably expected to be in or derived from the waste contained or deposited in the landfill facility (OAC 3745-27-10 [D][2]); and	—
• For inorganic parameters, the approved alternative monitoring parameter list will provide a reliable indication of inorganic releases from the landfill facility to the groundwater (OAC 3745-27-10 [D][3]).	Indicator parameters (e.g., specific conductance, total organic carbon, or total organic halogen), waste constituents, or reaction products that provide a reliable indication of the presence of hazardous constituents in groundwater (OAC 3745-54-98 [A])
Considerations:	
Types, quantities, and concentrations of constituents to be managed at the facility (OAC 3745-27-10 [D][2][b] and [D][3][a]);	Types, quantities, and concentrations of constituents to be managed at the regulated unit; (OAC 3745-54-98 [A][1])
• Mobility, stability, and persistence of the waste constituents or their reaction products in the unsaturated zone beneath the facility (OAC 3745-27-10 [D][3][b]);	Mobility, stability, and persistence of the waste constituents or their reaction products in the unsaturated zone beneath the waste management area (OAC 3745-54-98 [A][2])
• Concentrations in the leachate from the relevant unit(s) of the facility (OAC 3745-27-10 [D][2][c]);	—
• Detectability of the parameters, waste constituents, and their reaction products in the groundwater (OAC 3745-27-10 [D][3][c]);	Detectability of the indicator parameters, waste constituents, and their reaction products in the groundwater; (OAC 3745-54-98 [A][3]); and
• Concentrations or values and coefficients of variation of monitoring parameters or constituents in the background [baseline] groundwater quality (OAC 3745-27-10 [D][3][d]); and	Concentrations or values and coefficients of variation of monitoring parameters or constituents in the background (baseline) groundwater quality [OAC 3745-54-98 (A)(4)].
• Any other relevant information (OAC 3745-27-10 [D][2][d]).	–

Parameter selection focuses on establishing baseline conditions for the individual cells of the OSDF. Parameters selected for the baseline sampling and analysis approach of the OSDF groundwater monitoring program were selected using site-specific contamination data generated for the previous Operable Unit (OU) 5 Remedial Investigation (RI) Report (DOE 1995a) and the OU 5 Feasibility Study (FS) Report (DOE 1995b) in accordance with the regulatory considerations presented above.

The remainder of this section presents the site-specific monitoring parameters. These lists correspond to an alternate monitoring program parameters list as defined in the regulations. These indicator parameters will provide sufficient and reliable indication of potential releases from the OSDF.

3.0 Initial Leak Detection Monitoring Parameter List

An alternate leak detection monitoring parameters list should include both primary parameters and supplemental indicator parameters. As suggested by the regulatory considerations summarized in Table 1, primary parameters should consist of selected site-specific chemical constituents that are expected to be of significant amounts in the monitored facility, and that are persistent, mobile, and differentiable from existing background conditions when released. The supplemental indicator parameters may include general groundwater quality parameters, which will have rapid and detectable changes in response to variations in chemical compositions in groundwater under the monitored facility, potentially as a result of a leak.

The Initial Leak Detection Monitoring Parameter list consisted of fourteen primary parameters and four supplemental indicator parameters (i.e., initial baseline monitoring). Samples collected in all four monitoring horizons of each cell were sampled for these 18 parameters. Twelve rounds of sampling were completed at each cell. Following is the rationale that was used for the selection of the primary and supplemental indicator parameters.

3.1 Primary Parameters

In general, organic constituents are more mobile but less persistent than most inorganic constituents and radionuclides. Because inorganic constituents and most radionuclides are present in natural soil, if the OSDF were constructed in a pristine site, organic constituents may be the preferred primary monitoring parameters for early leak detection purposes. However, because all three types of constituents have been detected in the media (i.e., perched groundwater and the Great Miami Aquifer [GMA]), and because a monitoring parameter must be differentiable from background conditions in case of a release, a good leak detection monitoring parameter must also be present in significant abundance or at relatively high source strengths in the OSDF.

Constituent-specific quantity, persistence, and mobility data were considered during the development of the waste acceptance criteria (WAC) for the OSDF. Therefore, information from the OSDF WAC development process was first reviewed to select the primary parameters for leak detection monitoring purposes. The WAC for the OSDF were developed for 42 constituents during the OU5 FS (DOE 1995b); 41 of the WAC are included in the final OU5 Record of Decision (DOE 1996). (As discussed later, one compound—magnesium—was eliminated following completion of the FS.) As discussed in this section, 18 of the 41 WAC are numerical limits and 23 are non-numerical limits that were established to satisfy regulatory screening criteria for constituents regulated under the Resource Conservation and Recovery Act (RCRA).

The maximum acceptable leachate concentrations for constituents that will be present in the OSDF were determined by contaminant fate and transport modeling. The constituent-specific leaching potential, solubility, mobility, and benefits of the engineering controls in the OSDF were considered in the modeling process. These maximum acceptable leachate concentrations were converted into solid-phase WAC at the end of the process. These solid-phase WAC represent the maximum concentrations for soil and debris that can be disposed of in the OSDF.

To assist in selecting the primary parameters, the actual soil concentrations for each of the 18 COCs for which numerical WAC were developed were also reviewed to provide a clear perspective regarding which COCs may approach their corresponding WAC concentrations and, therefore, are more likely to be detectable when released from the OSDF.

During the OU5 FS (DOE 1995b), two categories of COCs were evaluated in the WAC development process. The first category includes all site-specific groundwater pathway COCs that were identified in the OU5 RI (DOE1995a). As a result of the process, 12 numerical WAC were developed for the groundwater pathway COCs. The second category includes those Fernald Preserve constituents that need to be managed and accounted for under RCRA regulations. Six additional numerical WAC were developed for the RCRA-regulated constituents, bringing the total numerical WAC for the OSDF to 18. The following subsections summarize the WAC development process for these two categories of constituents, as derived from the sitewide WAC development process described in the OU5 FS (DOE 1995b). Figure 1 summarizes the process in a flowchart.

3.1.1 Groundwater Pathway COCs

Initially, only the WAC for groundwater pathway COCs were developed. WAC were determined necessary for 15 groundwater pathway COCs selected from Table F.2–2 of Appendix F of the OU5 FS (DOE 1995b). Among all the detected soil and groundwater constituents at the Fernald Preserve, these 15 COCs have potential to reach and impact the GMA through the glacial till within 1,000 years under natural conditions (i.e., if they are not disposed of in the OSDF). Table F.2–2 of Appendix F of the OU5 FS also lists all the other constituents screened for potential cross-media impacts. Overall, 53 organics, 25 inorganics, and 15 radionuclides were evaluated in the groundwater COC selection process, including all the RCRA constituents that have been detected in soil and groundwater at the Fernald Preserve.

After consideration of the engineering controls provided by the OSDF in the modeling procedures, 12 of the original 15 groundwater pathway COCs were found to require numerical WAC. In a determination of which materials can be disposed of in the OSDF, compliance with the 12 numerical WAC will be required for the long-term protection of the GMA. Table 2 lists the 15 COCs considered and the WAC that were developed. The technical approach of fate and transport modeling conducted to develop the COC-specific WAC has been summarized in Section F.5 in the OU5 FS.

Upon further review of the initial WAC development process contained in the OU5 FS, the U.S. Environmental Protection Agency (EPA), the Ohio Environmental Protection Agency (Ohio EPA), and the U.S. Department of Energy (DOE) concurred that magnesium does not present a significant threat to human health. Therefore, magnesium was eliminated from further consideration, and a WAC for magnesium was not presented in Table 9–6 of the OU5 Record of Decision (DOE 1996).

The numerical WAC for the 12 groundwater pathway COCs were the main controlling factors for the disposal of contaminated soil in the OSDF. The 12 groundwater pathway COCs, which have numerical WAC, have significantly higher mobility and persistence and, therefore, should be considered prime candidates when selecting the indicator parameters for the detection monitoring program for the OSDF.

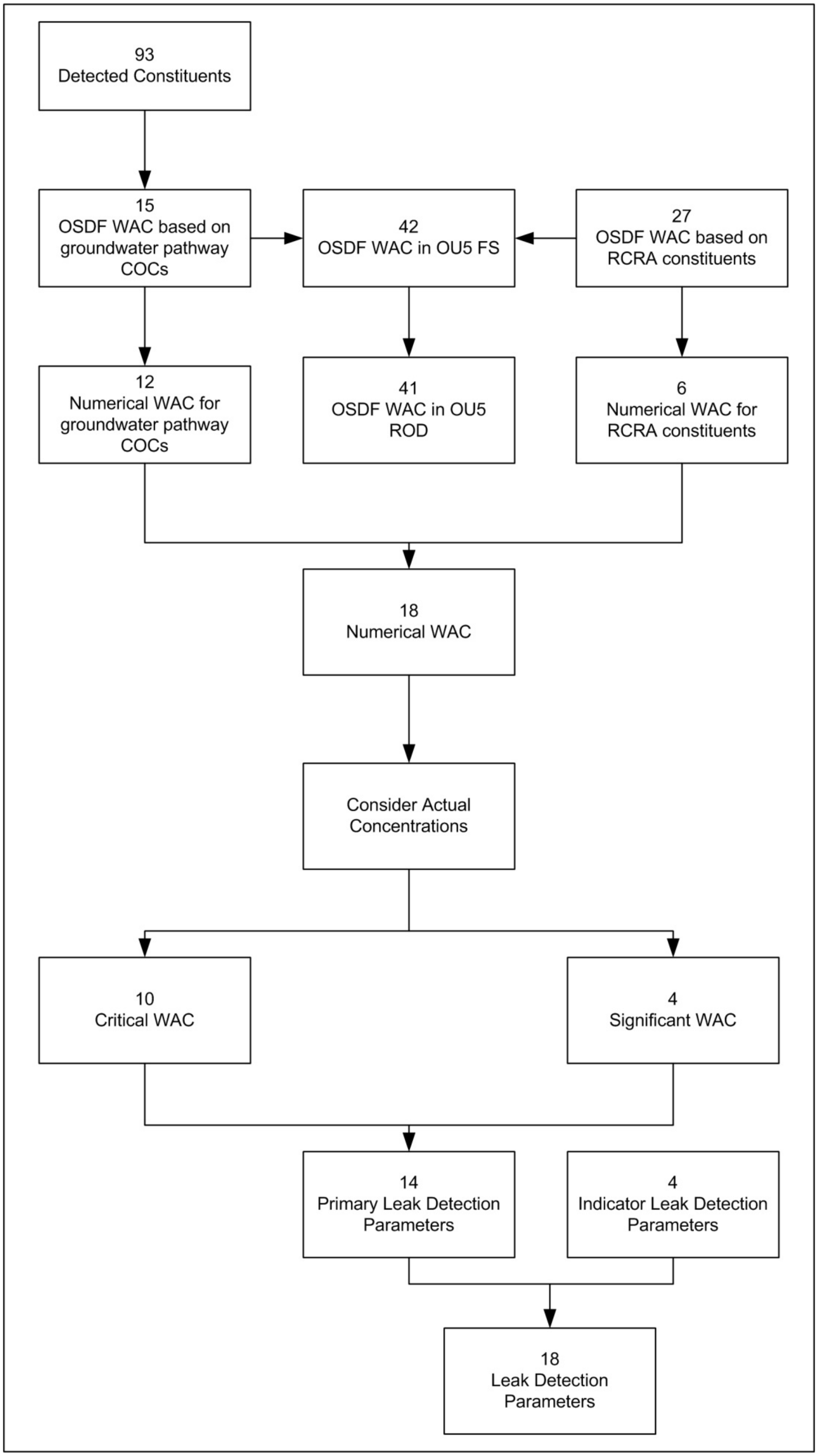

Figure 1. Groundwater/Leak Detection Parameter Selection Process

Table 2. WAC for Groundwater Pathway COCs

COC[a]	WAC
Radionuclides (pCi/g):	
Neptunium-237	3.12×10^{9}
Strontium-90	5.67×10^{10}
Technetium-99	2.91×10^{1}
Total Uranium (mg/kg)	1.03×10^{3}
Organics (mg/kg):	
alpha-Chlordane	2.89×10^{0}
Bis(2-chloroisopropyl)ether	2.44×10^{-2}
Bromodichloromethane	9.03×10^{-1}
Carbazole	7.27×10^{4}
1,2-Dichloroethane	*
4-Nitroaniline	4.42×10^{-2}
Vinyl Chloride[b]	1.51×10^{0}
Inorganics (mg/kg):	
Boron	1.04×10^{3}
Chromium VI[b]	*
Magnesium	*
Mercury[b]	5.66×10^{4}

[a]pCi/g = picocuries per gram
mg/kg = milligrams per kilogram
[b]RCRA constituent
*Denotes constituents that will not exceed designated GMA action level within 1,000-year performance period, regardless of starting concentration in the disposal facility.

The numerical WAC for the 12 groundwater pathway COCs in Table 2 only define the maximum allowable soil concentrations that can be safely disposed of in the OSDF; they do not indicate what level of soil concentrations will actually be encountered during soil remediation. In order to frame the relative significance of these 12 WAC, the maximum soil concentrations for the 12 constituents that are expected in the OSDF following soil placement are provided in Table 3.

As shown in Table 3, the expected maximum soil concentrations in the OSDF reveal that only five of the 12 groundwater pathway COCs with numerical WAC (technetium-99, total uranium, vinyl chloride, bis[2-chloroisopropyl]ether, and 4-nitroaniline) are expected to approach their respective WAC concentrations. The other seven COCs will have maximum soil concentrations in the OSDF that are much less than the corresponding WAC. This information regarding overall abundance is also an important consideration for selecting indicator parameters for the leak detection monitoring program.

Table 3. Expected Maximum COC Concentrations in the OSDF

COC	Maximum Concentration[a]	WAC	MAX/WAC
Radionuclides (pCi/g):			
Neptunium-237	2.63×10^{0}	3.12×10^{9}	8.43×10^{-10}
Strontium-90	6.49×10^{0}	5.67×10^{10}	1.14×10^{-10}
Technetium-99	2.91×10^{1}	2.91×10^{1}	1.00×10^{0}
Total Uranium (mg/kg)	1.03×10^{3}	1.03×10^{3}	1.00×10^{0}
Organics (mg/kg):			
alpha-Chlordane	5.10×10^{-3}	2.89×10^{0}	1.76×10^{-3}
Bis(2-chloroisopropyl)ether	2.44×10^{-2}	2.44×10^{-2}	1.00×10^{0}
Bromodichloromethane	7.00×10^{-3}	9.03×10^{-1}	7.75×10^{-3}
Carbazole	2.50×10^{-1}	7.27×10^{4}	3.44×10^{-6}
4-Nitroaniline	4.42×10^{-2}	4.42×10^{-2}	1.00×10^{0}
Vinyl Chloride[b]	1.51×10^{0}	1.51×10^{0}	1.00×10^{0}
Inorganics (mg/kg):			
Boron	1.43×10^{1}	1.04×10^{3}	1.38×10^{-2}
Mercury	1.30×10^{0}	5.66×10^{4}	2.30×10^{-4}

[a]Lower value between the WAC and the maximum soil concentration presented in Table F.3.4–3 of OU5 RI (DOE 1995a)
[b]Also consider tetrachloroethene and trichloroethene in soil.

3.1.2 RCRA Constituents

After the WAC for the groundwater pathway COCs were developed, WAC for 27 additional RCRA-regulated constituents (termed the RCRA COCs) were evaluated. The development of WAC for these specific constituents was considered necessary from a regulatory standpoint to address a requirement that the RCRA COCs not be eliminated in any COC screening step during the RI/FS process. The intention was to demonstrate compliance with RCRA regulations by providing a mechanism for keeping track of the fate of materials contaminated with RCRA constituents during the remediation.

Most of the RCRA COCs are not groundwater pathway COCs; thus, the calculated WAC for the majority of these constituents are relatively high (i.e., essentially pure product concentration). Only six of the additional constituents were determined to need a numerical WAC. The details of the RCRA constituent WAC development process are provided in Attachment F.5.I of the OU5 FS (DOE 1995b). Table 4 summarizes the results.

Table 4. WAC for Additional RCRA Constituents

RCRA Constituents	Detected and Previously Screened	WAC	OAC 3745-27-10 Appendix I
Organics (mg/kg):			
Acetone	Yes	*	Yes
Benzene	Yes	*	Yes
Carbon tetrachloride	Yes	*	Yes
Chloroethane	No	3.92×10^5	Yes
Chloroform	Yes	*	Yes
Chloromethane	No	*	Yes
1,1-Dichloroethane	Yes	*	Yes
1,1-Dichloroethene	Yes	1.14×10^1	Yes
1,2-Dichloroethene	No	1.14×10^1	Yes
Endrin	No	*	No
Ethylbenzene	Yes	*	Yes
Heptachlor	No	*	No
Heptachlor epoxide	No	*	No
Hexachlorobutadiene	No	*	No
Methoxychlor	No	*	No
Methylene chloride	Yes	*	Yes
Methyl ethyl ketone	Yes	*	Yes
Methyl isobutyl ketone	No	*	Yes
Tetrachloroethene	Yes	1.28×10^2	Yes
1,1,1-Trichloroethane	Yes	*	Yes
Trichloroethene	Yes	1.28×10^2	Yes
Toluene	Yes	*	Yes
Toxaphene	No	1.06×10^5	No
Xylenes	Yes	*	Yes
Inorganics (mg/kg):			
Barium	Yes	*	Yes
Lead	Yes	*	Yes
Silver	Yes	*	Yes

*Denotes constituents that will not exceed designated GMA action level within 1,000-year performance period, regardless of starting concentration in the disposal facility.

The six additional numerical WAC in Table 4 are actually not expected to affect any disposal decisions for contaminated waste, soil, and debris from OU2, OU3, and OU5. As shown in Table 4, the WAC for chloroethane and toxaphene are close to pure product concentration (i.e., 1.00×10^6 milligrams per kilogram [mg/kg]). The WAC for tetrachloroethene, trichloroethene, 1,1-dichloroethene, and 1,2-dichloroethene are higher than the highest detected soil concentrations, which were used in the previous screening process summarized in Table F.2–2 of the OU5 FS (DOE 1995b). The maximum detected soil concentrations presented in Table F.3.4–3 of the OU5 RI (DOE 1995a) for tetrachloroethene, trichloroethene, 1,1-dichloroethene, and 1,2-dichloroethene are 1.6×10^{0}, 8.90×10^{1}, 3.90×10^{-2}, and 3.4×10^{-1} mg/kg, respectively.

In general, the 15 groundwater pathway COCs listed in Table 2 already include all the constituents detected in soil and groundwater at the Fernald Preserve that may have potential to impact the GMA and, therefore, are more likely to be detectable in the monitoring system in case of a leak from the OSDF.

3.1.3 Selected Primary Parameters

Based on information presented in Tables 2 through 4, 14 constituents are considered to be the initial primary parameters list for OSDF leak detection monitoring purposes. Table 5 summarizes these constituents and the rationale for their selection. Table 5 also indicates whether each of the 14 constituents is listed in OAC 3745-27-10 Appendix I as a regulatory default parameter.

Table 5. Proposed Primary Parameters List

Constituents of Concern	Rationale	Appendix I
Radionuclides (pCi/g):		
Technetium-99	likely detectable when released	No
Total uranium (mg/kg)	likely detectable when released	No
Organics (mg/kg):		
alpha-Chlordane	likely detectable when released	No
Bis(2-chloroisopropyl)ether	likely detectable when released	No
Bromodichloromethane	likely detectable when released	Yes
Carbazole	likely detectable when released	No
1,1-Dichloroethene	significant RCRA constituent	Yes
1,2-Dichloroethene	significant RCRA constituent	Yes
4-Nitroaniline	likely detectable when released	No
Tetrachloroethene	significant RCRA constituent	Yes
Trichloroethene	significant RCRA constituent	Yes
Vinyl Chloride	likely detectable when released and significant RCRA constituent	Yes
Inorganics (mg/kg):		
Boron	likely detectable when released	No
Mercury	likely detectable when released and significant RCRA constituent	No

Four of the 18 constituents that have numerical WAC listed in Tables 2 or 4 (chloroethane, toxaphene, neptunium-237, and strontium-90) were not selected because of their expected actual maximum concentrations in the OSDF and their comparatively high WAC values that indicate less likely potential impacts and detectability in case of a leak from the OSDF. However, four RCRA constituents that are not groundwater pathway COCs (tetrachloroethene, trichloroethene, 1,1-dichloroethene, and 1,2-dichloroethene) were selected because their expected maximum soil concentrations are reasonably close to the WAC.

The 14 constituents identified in Table 5 that were selected as the primary leak detection monitoring parameters have a potential to enter the environment in measurable quantities and are likely to be more differentiable from background conditions. These 14 constituents will provide a reliable indication of potential releases from the OSDF to the groundwater. A possible exception may be boron, because it is present in the crushed carbonate stone used for the leachate collection system (LCS), leak detection system (LDS), and cap drainage layers.

3.2 Supplemental Indicator Parameters

In addition to the primary parameters discussed in the preceding subsection, four general groundwater contamination indicator parameters were also proposed to supplement the selected chemical constituents in the initial leak detection monitoring parameters list. These supplemental indicator parameters consist of the following:

- pH
- Specific Conductance
- Total Organic Halogens (TOX)
- Total Organic Carbon (TOC)

These general groundwater contamination indicator parameters are typically used to aid in the detection of releases from disposal facilities. However, given that the largest volume of material placed in the cell is contaminated glacial till (made up of approximately 50 percent carbonate grains by volume), the pH of leachate will not be appreciably different from the pH of perched water or groundwater in the GMA. Therefore, the remaining three supplemental indicator parameters provide an added means to detect contaminant migration and will be useful as indicators for general groundwater quality degradation.

Although the initial indicator parameters should provide indications of potential releases throughout the operational life of the OSDF, efficiency of the parameters list may still be improved based on the collected data obtained over the course of the program. Any proposed modifications based on the accumulated database will involve EPA and Ohio EPA review and approval before adoption.

4.0 Parameter Lists

The sections above identify the process that was used for selecting parameters for initial baseline sampling and analysis (i.e., site-specific leak detection indicator parameters, which are the proposed primary parameters in Table 5, and the supplemental indicator parameters listed in Section 3.2 of this appendix).

Twelve rounds of sampling for the initial site-specific leak detection monitoring parameters were completed at all eight cells in 2007. At the completion of the 12 rounds of sampling, five parameters were identified as having been detected at least 25 percent of the time. These five parameters (boron, sulfate, uranium, TOC, and TOX) make up the refined baseline for each cell.

In 2002 there were relatively high concentrations of sulfate in the Cells 4 and 5 LCS water prior to waste placement, indicating a sulfate source (possibly gypsum) in the gravel composing the LCS layer. Due to sulfate's high mobility and the presence of an ongoing source in the LDS/LCS layers, it was added to the leak detection sampling program in 2003.

Establishing baseline water chemistry in the perched groundwater and GMA horizon under each cell is complicated by the construction process used to install the horizontal till wells (HTWs) and the presence of past groundwater contamination in the till and GMA zones. The installation of the HTWs involved excavation of a trench, placement of a porous filter media composed of sand, and then backfill with the porous media and till material. During this installation, the subsurface chemical properties of the till were altered by the contact of the excavated till material with the atmosphere (oxygen-rich environment). Contact of the subsurface till with the atmosphere may have impacted (1) the oxidation state of metals on the surface of grains and in the pore water and (2) microbial species that mediate oxidation-reduction reactions in the subsurface. Additionally, historical contamination in perched groundwater and GMA horizons surrounding the cell may be migrating and diffusing into the horizontal and GMA monitoring wells.

To address some of these uncertainties, DOE conducted a common-ion study. Results of the study were presented in a report titled *Evaluation of Aqueous Ions in the Monitoring Systems of the On-Site Disposal Facility* (DOE 2008a). The report identified four additional constituents (iron, manganese, sodium, and lithium) as potentially beneficial monitoring parameters. These four additional constituents are monitored in the LCS, LDS, and GMA wells of each cell.

In addition to sampling for the approved initial baseline constituents, refined baseline constituents, and the selected common-ion constituents, DOE continued to sample the LCS once a year for the full list of Appendix I (OAC 3745-27-10) and polychlorinated biphenyl (PCB) constituents. A statistical screening process was developed (Figures 2 and 3) to evaluate the results of the continued sampling with the objective of determining if any constituent not already on the alternate parameter list might also be a useful monitoring constituent. The screening process was initially presented in the 2007 Site Environmental Report, and was conducted once a data set of eight samples was available for a cell. The screening process has been conducted for all 8 Cells, and the results have been reported as follows:

- Cells 1, 2, and 3 reported in the *Fernald Preserve 2007 Site Environmental Report* (DOE 2008b).
- Cells 4 and 5 reported in the *Fernald Preserve 2009 Site Environmental Report* (DOE 2010).
- Cell 6 reported in the *Fernald Preserve 2010 Site Environmental Report* (DOE 2011).
- Cells 7 and 8 reported in the *Fernald Preserve 2011 Site Environmental Report* (DOE 2012).

The assessment process was based on showing statistically that the average LCS concentration was greater than either the pre-design or background average concentration. A constituent with a greater average LCS concentration than either pre-design or background was added to the monitoring list for deeper horizons. The resulting monitoring list contained 24 parameters to be sampled for in all horizons, except the HTW. Beginning in January 2014, sampling frequency was reduced from quarterly to a semiannual sampling frequency.

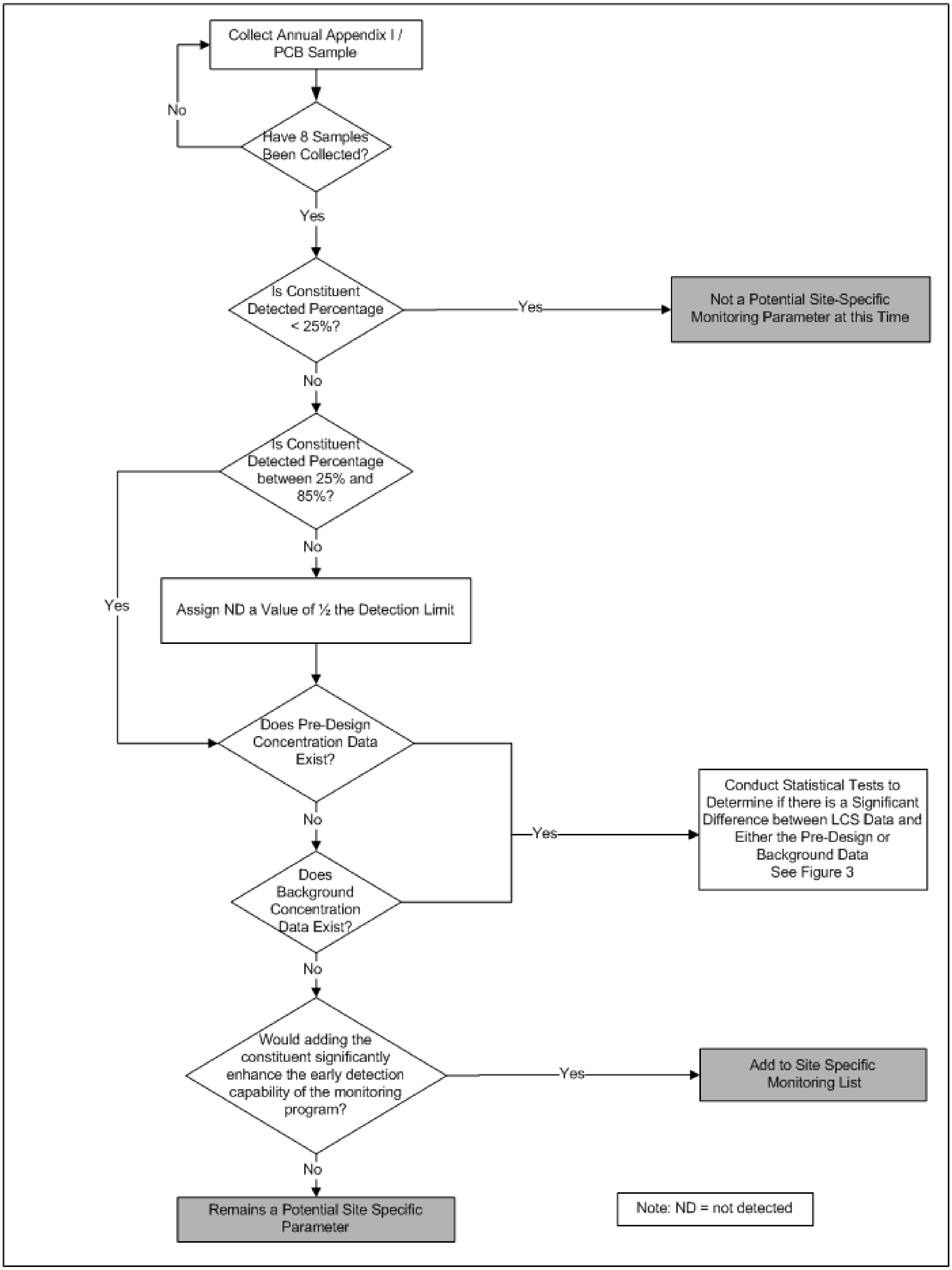

Figure 2. OSDF Site-Specific Leachate Monitoring Parameter Selection Approach

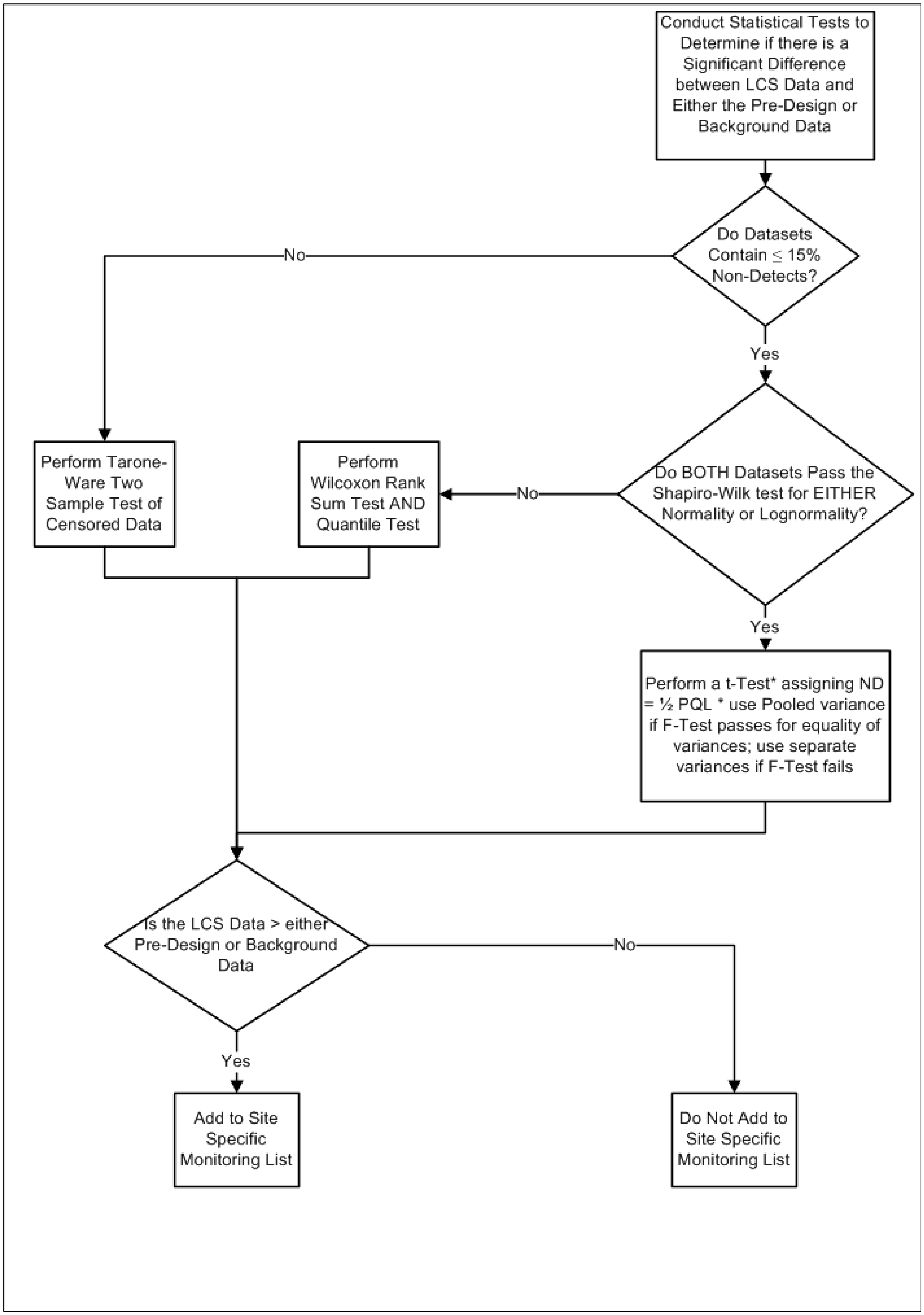

Figure 3. OSDF Site-Specific Leachate Monitoring Parameter Selection Statistical Testing Approach

Monitoring List

Parameter	Source for Selection
Uranium	Refined Baseline
Boron	Refined Baseline
TOC	Refined Baseline
TOX	Refined Baseline
Sulfate	Refined Baseline
Iron	Common Ion Report[a]
Lithium	Common Ion Report[a]
Manganese	Common Ion Report[a]
Sodium	Common Ion Report[a]
Arsenic	Screened in 2007
Cobalt	Screened in 2007
Nickel	Screened in 2007
Selenium	Screened in 2007
TDS[b]	Screened in 2007
Zinc	Screened in 2007
Alkalinity	Screened in 2009
Barium	Screened in 2009
Calcium	Screened in 2009
Chloride	Screened in 2009
Copper	Screened in 2009
Magnesium	Screened in 2009
Nitrate/nitrite	Screened in 2009
Potassium	Screened in 2009
Chromium	Screened in 2011

Note: Technetium-99 is also sampled in Cell 8 only.
[a] *Evaluation of Aqueous Ions in the Monitoring Systems of the On-Site Disposal Facility* (DOE 2008a)
[b]TDS = total dissolved solids

Because all eight cells have gone through the parameter selection statistical screening process, annual sampling in the LCS continues for an agreed to modified Appendix I parameter list found in Table 1 of Appendix B.

Ohio EPA proposed reducing the list of parameters being sampled in the HTW to just uranium, arsenic, and tritium (beginning in the second quarter of 2011). Sampling for tritium in all horizons was agreed to for a year. Tritium was added to the list of constituents because it was hoped that it might serve as a useful monitoring parameter. Tritium was used in exit signs, which may be in the OSDF with other building materials. Tritium has a relatively short half-life (approximately 12 years) but is fairly mobile and, if present, could be a good potential leak indicator parameter. One year of tritium sampling results indicated that tritium was not a good monitoring parameter for the OSDF. Therefore, tritium is no longer sampled for in any of the monitoring horizons. In addition to sampling the HTWs for uranium and arsenic, DOE also samples for sodium and sulfate in order to prepare bivariate plots. Bivariate plots are useful in illustrating that the chemical signatures of the different monitoring horizons (LCS, LDS, HTW) are separate and distinct.

4.1 Adding Monitoring Parameters to Sampling Lists

A review of the LCS water quality data will be conducted (and reported through the annual Site Environmental Reports) to determine if a constituent that is only sampled for annually in an LCS should be sampled semiannually.

If a constituent that is only sampled for annually in the LCS is detected, the detection will be confirmed in the LCS during the next scheduled sampling round. Two consecutive detects in a cell's LCS will trigger sampling in the cell's LDS during the next scheduled sampling event. Two consecutive detects in a cell's LDS will trigger sampling in the cells GMA wells.

5.0 References

DOE (U.S. Department of Energy), 1995a. *Remedial Investigation Report for Operable Unit 5*, Final, Fernald Environmental Management Project, Cincinnati, Ohio, March.

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