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Primary Document

Work Plan for the Burial Grounds Operable Unit Remedial Investigation/Feasibility Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

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Work Plan for the Burial Grounds Operable Unit Remedial Investigation/Feasibility Study at Paducah Gaseous Diffusion Plant Paducah, Kentucky

Date Issued—August 2006

Prepared for the
U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
PADUCAH REMEDIATION SERVICES, LLC
managing the
Environmental Remediation Activities at the
Paducah Gaseous Diffusion Plant
under contract DE-AC30-06W05001

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ACRONYMS

%R	percent recovery
90DAA	90-Day Accumulation Area
ACGIH	American Conference of Governmental Industrial Hygienists
ACO	Administrative Consent Order
AHA	activity hazard analysis
ALARA	as low as reasonably achievable
amsl	above mean sea level
ANSI	American National Standards Institute, Inc.
AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
ASB	angled soil boring
ASTM	American Society for Testing and Materials
AT123D	Analytical Transient 1-,2-,3- Dimensional
BGOU	Burial Grounds Operable Unit
bgs	below ground surface
BHHRA	baseline human health risk assessment
BJC	Bechtel Jacobs Company LLC
BRA	baseline risk assessment
BTEX	benzene, toluene, ethyl benzene, and xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLA AOC	CERCLA area of contamination
CFR	Code of Federal Regulations
COC	contaminant of concern
COE	U.S. Army Corps of Engineers
COPC	chemical of potential concern
CPR	cardiopulmonary resuscitation
CRZ	Contamination Reduction Zone
CZ	Construction Zone
D&D OU	Decontamination and Decommissioning Operable Unit
DAF	dilution/attenuation factor
dBA	decibel
DCE	dichloroethene
DMC	Document Management Center
DMIP	data management implementation plan
DNAPL	dense nonaqueous-phase liquid
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DPT	direct push technology
DQO	data quality objective
DWRC	dual-wall reverse circulation
dtw	depth to water
EDD	electronic data deliverable
Eh	oxidation reduction potential
EM	electromagnetic
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ES&H	Environment, Safety, and Health

EZ	Exclusion Zone
FCR	Field Change Request
FFA	Federal Facility Agreement
FS	feasibility study
FSP	field sampling plan
FTM	Field Team Manager
GDP	gaseous diffusion plant
Ge	Germanium
GET	General Employee Training
GIS	geographic information system
GPR	Ground Penetrating Radar
GSA	Generator Staging Area
GWOU	Groundwater Operable Unit
HAZCOM	hazard communications
HMIS	Hazardous Material Inventory System
HSA	hollow-stem auger
HSWA	Hazardous and Solid Waste Amendments
HU	hydrostratigraphic unit
IDW	investigation-derived waste
ISMS	Integrated Safety Management System
KAR	Kentucky Administrative Record
KDEP	Kentucky Department for Environmental Protection
KPDES	Kentucky Pollutant Discharge Elimination System
KSNPC	Kentucky State Nature Preserves Commission
LLW	low-level waste
MARLAP	Multi-Agency Radiological Laboratory Analytical Protocols
MCL	maximum contaminant level
MDL	method detection limit
MEPAS	Multimedia Environmental Pollutant Assessment System
mrem	millirem
MS	matrix spike
MSD	matrix spike duplicate
MSDS	material safety data sheet
MW	monitoring well
NCR	Nonconformance Report
NEPA	National Environmental Policy Act
NIST	National Institute of Standards and Technology
^{237}Np	neptunium-237
NPL	National Priorities List
NSDD	North-South Diversion Ditch
OA	observational approach
OREIS	Oak Ridge Environmental Information System
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCB	polychlorinated biphenyl
PEMS	Project Environmental Measurements System
PGDP	Paducah Gaseous Diffusion Plant

pH	negative logarithm of the hydrogen-ion concentration
PID	photoionization detector
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
PRG	preliminary remediation goal
PSS	Plant Shift Superintendent
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RADCON	radiation control
RCRA	Resource Conservation and Recovery Act
RCT	Radiological Control Technician
RESRAD	Residual Radioactive Materials
RFD	Request for Disposal
RGA	Regional Gravel Aquifer
RGO	remedial goal option
RI	remedial investigation
RPP	Radiological Protection Program
RTL	ready-to-load
RWP	Radiological Work Permit
SADA	Statistical Analysis and Decision Assistance
SERA	screening-level ecological risk assessment
SESOIL	Seasonal Soil Compartment Model
SI	site investigation
SMO	Sample Management Office
SMP	site management plan
SOP	standard operating procedure
SOU	Soils Operable Unit
SOW	statement of work
SVOC	semivolatile organic compound
SWMU	solid waste management unit
SWOU	Surface Water Operable Unit
TAL	target analyte list
^{99}Tc	technetium-99
TCA	trichloroethane
TCE	trichloroethene
TCL	target compound list
TCLP	Toxicity Characteristic Leaching Procedure
^{234}Th	thorium-234
TRU	transuranic waste
TSCA	Toxic Substances Control Act
TSDF	treatment, storage, and disposal facility
TVA	Tennessee Valley Authority
^{235}U	uranium-235
^{238}U	uranium-238
UCRS	Upper Continental Recharge System
UF_6	uranium hexafluoride
USRAD	Ultrasonic Ranging and Data
VOC	volatile organic compound

VSB	vertical soil boring
WAC	waste acceptance criteria
WAG	Waste Area Grouping
WGP	Waste Generation Plan
WKWMA	West Kentucky Wildlife Management Area
WMC	Waste Management Coordinator
WMP	waste management plan

EXECUTIVE SUMMARY

The Paducah Gaseous Diffusion Plant (PGDP) is an active uranium enrichment facility that is owned by the U.S. Department of Energy (DOE). DOE is conducting environmental restoration activities at PGDP in accordance with the requirements of the Commonwealth of Kentucky and the U.S. Environmental Protection Agency (EPA) under the Paducah Federal Facility Agreement (FFA) and the Comprehensive Environmental Response, Compensation, and Liability Act. PGDP was placed on the National Priorities List in 1994. DOE, EPA, and the Commonwealth of Kentucky entered into the FFA in 1998 (EPA 1998).

This Remedial Investigation/Feasibility Study (RI/FS) Work Plan has been developed to outline the RI/FS requirements for the Burial Grounds Operable Unit (BGOU) at PGDP. The solid waste management units (SWMUs) associated with the BGOU are SWMUs 2, 3, 4, 5, 6, 7 and 30, and 145. Included in this document is a compilation of sampling information collected on and around PGDP over the course of the last ten years. The table below identifies the previously completed reports and/or investigations primarily used to prepare this RI/FS Work Plan.

Table ES.1 Summary of Previous Assessments of On-site Portions of BGOU

Dates	Title	SWMU 2	SWMU 3	SWMU 4	SWMU 5	SWMU 6	SWMU 7	SWMU 30	SWMU 145
1989	Post Closure Permit Application C-404 Low-Level Radioactive Waste Burial Ground		✓						
1996	Closure Plan C-404 Low-Level Radioactive Waste Burial Ground		✓						
1996–1997	WAG 22 SWMUs 2 and 3 Remedial Investigation and Addendum	✓	✓						
1996–1998	WAG 22 SWMUs 7 and 30 RI/FS						✓	✓	
1998–2001	WAG 3 RI/FS			✓	✓	✓			
1999–2001	Data Gaps Investigation			✓	✓		✓	✓	✓
2000–2001	Old North-South Diversion Ditch Sampling								✓
2002–2003	Scrap Yards Site Characterization				✓	✓	✓	✓	
2003–2004	C-746-S&T Landfill Site Investigation								✓
2004	Southwest Plume Site Investigation			✓					

WAG = waste area grouping

PROJECT GOALS AND OBJECTIVES

The goals for the BGOU RI/FS are consistent with those established in the FFA and the Paducah Site Management Plan (SMP) (DOE 2004a) negotiated among DOE, EPA, and the Kentucky Department for Environmental Protection. The FFA requires that PGDP identify, investigate, and remediate all areas of concern and SWMUs that pose a threat to human health and the environment. The goals of this RI/FS are as follows:

- Goal 1: Characterize Nature of Source Zone—Characterize the nature of contaminant source materials by using existing data and, if required, by collecting additional data;

- Goal 2: Define Extent of Source Zone and Contamination in Soil and Other Secondary Sources at All Units—Define the nature, extent (vertical and lateral), and magnitude of contamination in soils, sediments, surface water, and groundwater by using existing data and, if required, by collecting additional data; determine the presence, general location (if practicable), and magnitude of any dense nonaqueous-phase liquid zones as defined in the Paducah SMP (DOE 2004a);

- Goal 3: Determine Surface and Subsurface Transport Mechanisms and Pathways—Gather existing quality data and, if necessary, collect additional adequate-quality data to analyze contaminant transport mechanisms, evaluate risk, and support an FS; and

- Goal 4: Support Evaluation of Remedial Technologies—Determine if the existing data are sufficient to evaluate alternatives that will reduce risk to human health and the environment and/or control the migration of contaminants off-site.

During development of this work plan, existing data were evaluated relative to the data quality objectives defined in this work plan. The evaluation shows that either data gaps exist for a SWMU or that sufficient data are available to move forward with an FS. The table below is a summary of the data gaps identified that will be addressed by implementation of this work plan.

Table ES.2 Summary of Additional Data Needs for the BGOU

SWMU	Summary of Additional Data Needs
SWMU 2	**Data Gaps:** There are no soil or groundwater data at depth adjacent to the burial ground or from beneath the burial ground. The potential for additional contaminants (other than what have been identified in previous investigations) seeping from the bottom of the burial cell is unknown. The potential that the soils immediately beneath the burial pits have become contaminated and are now a secondary contaminant source is unknown. The SWMU is located above a trichloroethene (TCE) plume; however, upgradient and downgradient data that might indicate whether SWMU 2 is contributing to this plume are not available. There is no suitable upgradient or downgradient well from which background samples have been collected. **Sampling Strategy:** Drill two angle borings under the burial area and collect soil samples and Upper Continental Recharge System (UCRS) groundwater samples (if sufficient amount of groundwater is available). Sample existing Regional Gravel Aquifer (RGA) upgradient and downgradient wells, or install and sample new upgradient and downgradient wells. These wells will be upgradient and downgradient to SWMUs 2 and 3.

Table ES.2 Summary of Additional Data Needs for the BGOU (continued)

SWMU	Summary of Additional Data Needs
SWMU 3	**Data Gaps:** There are no soil data at depth immediately adjacent to the impoundment or from beneath the impoundment. Because the SWMU is located above a TCE plume, upgradient and downgradient data are not available that might indicate whether SWMU 3 is contributing to this plume; however, the current well network is being impacted by the existing TCE plume. There is no information on potential subsurface soil contamination directly beneath the burial pits. The potential is unknown for additional contaminants (other than what have been identified in previous investigations) seeping from the bottom of the burial cell. The potential is unknown that the soils immediately beneath the burial pits may have become contaminated and are now a secondary contaminant source. There are no surface or subsurface soil historical data along the ditches around SWMU 3 and along the ditch leading to the North-South Diversion Ditch (NSDD). **Sampling Strategy:** Drill four angle borings around, and under, the burial cell, and collect soil samples and UCRS groundwater samples (if sufficient amount of groundwater is available). Sample existing RGA upgradient and downgradient wells (not part of the current network), or install and sample new upgradient and downgradient wells. These wells will be upgradient and downgradient to SWMUs 2 and 3. Collect surface and shallow subsurface soil samples from six vertical borings from the ditches and ditch leading to the NSDD.
SWMU 4	**Data Gaps:** None identified. The site has been characterized sufficiently to meet RI/FS goals.
SWMU 5	**Data Gaps:** Previous investigations did not fully characterize the waste stream, based on existing records of waste disposal. **Sampling Strategy:** Drill three angle borings around SWMU 5, in targeted areas. Collect soil samples and UCRS groundwater samples (if sufficient amount of groundwater is available).
SWMU 6	**Data Gaps:** Areas have not been evaluated where there was radiologically-contaminated equipment stored during previous investigations. **Sampling Strategy:** Drill four angle borings near their separate corresponding pits where the highest contamination was found previously. Collect soil samples and UCRS groundwater samples (if sufficient amount of groundwater is available).

Table ES.2 Summary of Additional Data Needs for the BGOU (continued)

SWMU	Summary of Additional Data Needs
SWMUs 7 and 30	**Data Gaps:** There is no information on potential subsurface soil contamination directly beneath the burial pits. The potential is unknown for additional contaminants (other than what have been identified in previous investigations) seeping from the bottom of the burial cell. The potential is unknown that the soils immediately beneath the burial pits may have become contaminated and are now a secondary contaminant source. The lateral extent of the burial pits is not definitively known. **Sampling Strategy:** Conduct a geophysical survey to determine the pit boundaries where uncertainties have been identified and to define the anomalous areas. Drill twelve angle borings (one under each pit) and collect soil samples and UCRS groundwater samples (if sufficient amount of groundwater is available). Drill one vertical boring at the former Drum Mountain location and collect soil samples and UCRS groundwater samples (if sufficient amount of groundwater is available). Drill two vertical borings north of the pits and collect soil samples and groundwater samples to evaluate TCE contamination in shallow groundwater.
SWMU 145	**Data Gaps:** There is no information on potential subsurface soil contamination directly beneath the burial pits. The potential is unknown for additional contaminants (other than what have been identified in previous investigations) seeping from the bottom of the burial cell. The potential is unknown that the soils immediately beneath the burial pits may have become contaminated and are now a secondary contaminant source. The exact location of burial cells within the SWMU is unknown. **Sampling Strategy:** Conduct a geophysical survey to determine the pit boundaries where uncertainties have been identified. Drill seven angle borings and collect soil samples and UCRS groundwater samples (if sufficient amount of groundwater is available). If geophysical survey does not determine appropriate pits to angle beneath, then the angle and boring location may be placed so as not to endanger the environment or the safety of the workers.

1. INTRODUCTION

The Paducah Gaseous Diffusion Plant (PGDP), located within the Jackson Purchase region of Western Kentucky, is an active uranium enrichment facility that is owned by the U.S. Department of Energy (DOE). PGDP was owned and managed, first by the Atomic Energy Commission and the Energy Research and Development Administration, DOE's predecessors; DOE then managed PGDP until 1993. On July 1, 1993, the United States Enrichment Corporation assumed management and operation of the PGDP enrichment facilities under a lease agreement with DOE. DOE, however, still owns the enrichment complex and is responsible for environmental restoration (ER) activities associated with legacy operation of PGDP (CERCLIS #KY8-890-008-982). DOE is the lead agency for remedial actions, and the U.S. Environmental Protection Agency (EPA) and the Kentucky Department for Environmental Protection (KDEP) have regulatory oversight responsibilities.

In July 1988, off-site groundwater contamination was detected in groundwater wells north of PGDP. In August 1988, DOE and EPA Region 4 entered into an Administrative Consent Order (ACO) under Section 104 and 106 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In May 1994, PGDP was placed on the National Priorities List (NPL), a list of sites designated by EPA as having the highest priority for site remediation. Additionally, Section 120 of CERCLA requires NPL sites to enter into a Federal Facility Agreement (FFA). An FFA was finalized among DOE, EPA, and the Commonwealth of Kentucky in February 1998.

Source units and areas of contamination at PGDP have been combined into operable units (OUs) for evaluation of remedial actions. These OUs include the Surface Water Operable Unit (SWOU), the Burial Grounds Operable Unit (BGOU), the Soils Operable Unit (SOU), the Groundwater Operable Unit (GWOU), and the Decontamination and Decommissioning Operable Unit (D&D OU). Each OU is designed to remediate contaminated media associated with PGDP. The SWOU is directed at remediating the surface water bodies, including the outfall ditches, impoundment ponds, and Little Bayou and Bayou Creeks. The SOU is designed to remediate the contaminated soils associated with the plant not located in a waterway, outfall, ditch, or burial grounds. The BGOU scope addresses the contamination that is associated with the PGDP landfills and burial grounds. The GWOU will develop and implement remedial alternatives for contaminants of concern (COCs) associated with the groundwater beneath and near PGDP. The scope of the D&D OU includes 17 currently inactive DOE facilities, those solid waste management units (SWMUs) and areas of concern (AOCs) designated as being associated with gaseous diffusion plant (GDP) operations, and associated with current operating GDPs. Once the BGOU, SWOU, GWOU, SOU, and D&D OU are complete, a Comprehensive Site-Wide OU will be conducted (DOE 2000a).

The subject of this work plan is the BGOU (SWMUs 2, 3, 4, 5, 6, 7 and 30, and 145). Figure 1.1 identifies the locations of these SWMUs in relation to PGDP. With the exception of SWMU 145, these SWMUs are located within the plant secured area.

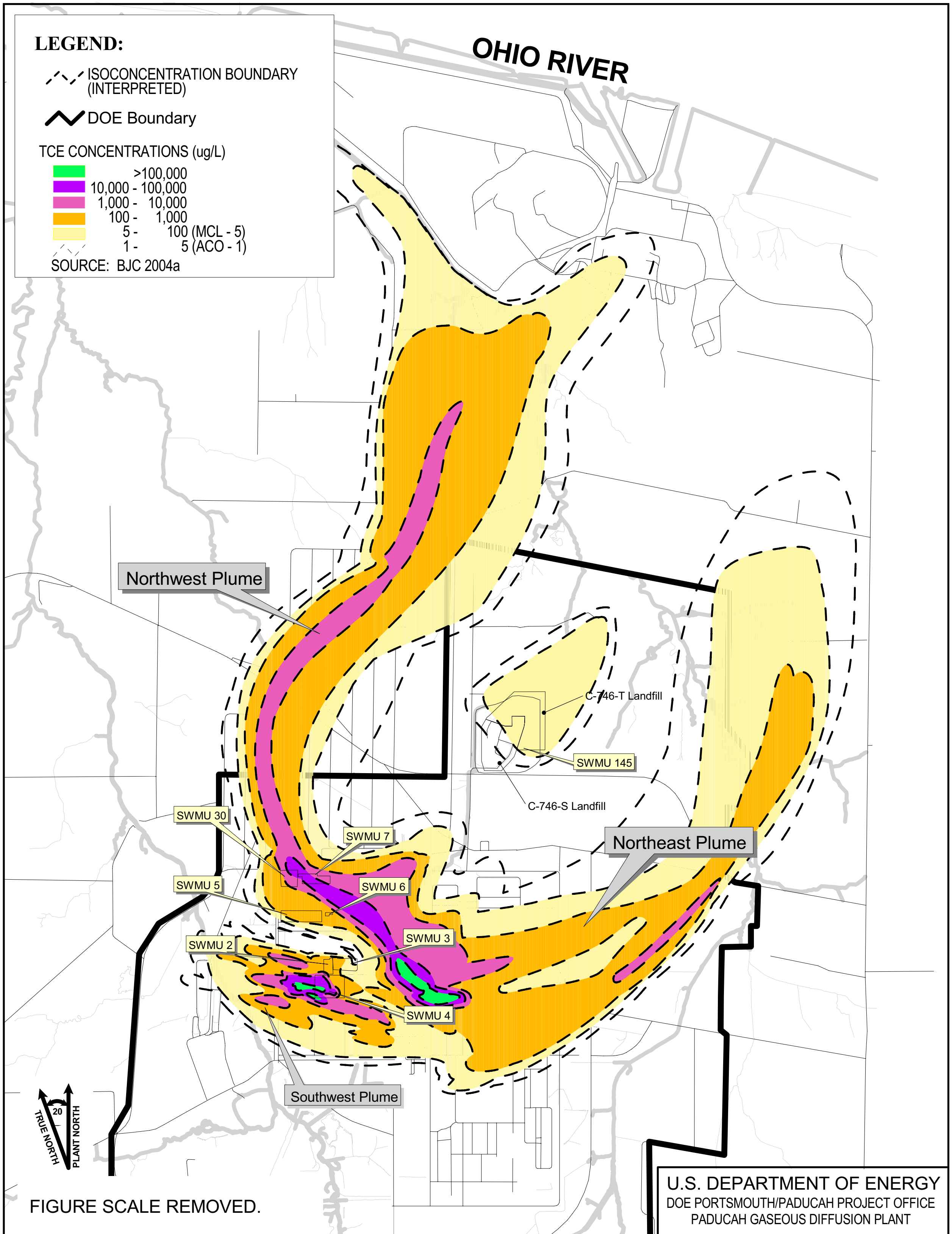

Figure 1.1. BGOU SWMUs and Groundwater Plumes at PGDP

Figure No. \BGOU\bgwpmap.apr
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1.1 PROJECT SCOPE

The general scope of this project is to provide a document identifying the data available and the data required to conduct a Remedial Investigation/Feasibility Study (RI/FS) for the BGOU located within and near PGDP. The primary focus of this work plan is to collect existing information about contamination in and around the SWMUs and determine what additional data are required to support an assessment of risks to human health and the environment, and support future decisions regarding the selection of actions to reduce these risks.

The scope includes an RI, baseline risk assessment (BRA), evaluation of remedial alternatives, remedy selection, and implementation of actions, as necessary, for protection of human health and the environment for the following burial grounds: C-749 (SWMU 2); C-404 (SWMU 3); C-747 (SWMU 4); C-746-F (SWMU 5); C-747-B (SWMU 6); C-747-A (SWMUs 7 and 30, which includes the area beneath SWMU 12); the residential/inert borrow area and old North-South Diversion Ditch (NSDD) disposal trench (SWMU 145); and additional disposal areas that might exist beneath the scrap yards (DOE 2004a). Project uncertainties that potentially could affect the scope and schedule include the amount and scope of RI characterization needed (e.g., test pits, angle borings) and whether additional actions beyond capping will be required. The April 2004 Paducah Site Management Plan (SMP) agreement established a submittal date for a D1 RI/FS Work Plan of June 30, 2005. This submittal was met.

Secure On-Site Source Units. For all secure on-site source units (sites within the PGDP security area), the focus of the investigation will not necessarily fall within the boundary of the surface area of the SWMU and the water table below the unit. The focus of the investigation at these units will be soil contamination at the unit and any secondary contamination sources from the unit located in the subsurface soil and groundwater.

Relationship of Source Units to the Other OU Remedial Studies. Data collected during the BGOU RI/FS will be incorporated into remedial studies of the GWOU and SWOU. For groundwater, vadose-zone and Upper Continental Recharge System (UCRS) data may be used in the development of the facility-wide groundwater flow and solute transport models. Incorporation of these data will allow the significant sources of groundwater contamination to be considered in the human health risk assessment of the GWOU. Data collected during the RI/FS concerning contaminant migration to the SWOU may be used in the development of the facility-wide surface water transport models needed for the SWOU human health and ecological risk assessments.

The BGOU will focus on the burial cells and the immediately affected area adjacent and under the cells down to the Regional Gravel Aquifer (RGA) to determine if the cells are contributing to groundwater contamination. The nature and extent and remediation of the groundwater will be addressed in the GWOU activities.

Surface soils and sediments within the BGOU SWMUs will not be included in the BGOU RI/FS. Contaminant investigation and remediation for surface soils and sediments in the BGOU SWMUs will be included in the SOU and the SWOU activities.

Remedial or Removal Actions. If remedial or removal actions are implemented at any of the SWMUs addressed in this work plan before the development of a final remedy, they will be consistent with the anticipated final action for the BGOU and will contribute to the final remediation of the site. The setting under which remedial alternatives will be screened at a SWMU will be determined at the time the remedial action objectives for the BGOU are developed.

The RI/FS process is an interactive one in which EPA, KDEP, DOE, DOE Prime Contractors, and others evaluate and approve or revise work conducted during various stages of the investigation. The first stage involves implementation of the RI/FS Work Plan. Flexibility will be included in the sampling plans for each SWMU to allow some adjustments to be made in the field. Unexpected contaminant levels or subsurface conditions may require changes to the plans.

This RI/FS Work Plan has been prepared to implement additional investigations for the BGOU to provide information to fill identified data gaps. The document utilizes a compilation of sampling information collected at, and around, PGDP over the course of the last ten years. Data were compiled and screened against primary contaminants of concern listed in the *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Vol. 1: Human Health* (DOE 2000b). The need for additional sampling has been determined consistent with sound technical principles and the *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Vol. 1: Human Health* (DOE 2000b).

This work plan utilizes the data quality objective (DQO) process as a planning tool to assist in the identification of environmental problems and to define the data collection process needed to support decisions regarding the problem associated with the BGOU.

The BGOU RI/FS Work Plan follows the outline prescribed in the FFA.

1.2 PROJECT OBJECTIVES AND GOALS

The goals for the BGOU RI/FS are consistent with those established in the FFA and the SMP negotiated among DOE, EPA, and KDEP. The FFA requires that PGDP identify, investigate, and remediate AOCs and SWMUs that pose a threat to human health and the environment. The goals of this RI/FS are as follows:

- Goal 1: Characterize Nature of Source Zone—Characterize the nature of contaminant source materials using existing data and, if required, by collecting additional data;

- Goal 2: Define Extent of Source Zone and Contamination in Soil and Other Secondary Sources at All Units—Define the nature, extent (vertical and lateral), and magnitude of contamination in soils, sediments, surface water, and groundwater by using existing data and, if required, by collecting additional data; determine the presence, general location (if practicable), and magnitude of any dense nonaqueous-phase liquid (DNAPL) zones as defined in the Paducah SMP (DOE 2004a);

- Goal 3: Determine Surface and Subsurface Transport Mechanisms and Pathways—Gather existing quality data and, if necessary, collect additional adequate-quality data to analyze contaminant transport mechanisms, evaluate risk, and support an FS; and

- Goal 4: Support Evaluation of Remedial Technologies—Determine if the existing data are sufficient to evaluate alternatives that will reduce risk to human health and the environment and/or control the migration of contaminants off-site.

1.3 PROJECT DATA QUALITY OBJECTIVES

The DQO process was used to focus the sampling strategy on SWMU-specific media, contamination, and migration pathways. This process also was used to identify the data requirements for the BRA and

FS. To facilitate this activity, existing data on the SWMU process, waste management, releases, and environmental site conditions were gathered and are presented in this document. The DQO process is a planning tool, based on the scientific method, that identifies an environmental problem and defines the data collection process needed to support decisions regarding that problem [*Data Quality Objectives Process for Superfund*, Interim Final Guidance (EPA 1993)]. The steps outlined in the DQO process were used in the development of this RI/FS Work Plan. These steps formulate a set of criteria that will achieve the desired control of uncertainty, allowing the decision to be made with acceptable confidence. In establishing DQOs, it is important to follow the sequence of the stages, because the product of each stage forms the foundation for subsequent stages.

The first step in the DQO process is to identify the problem to be resolved. It is possible that contaminants originating from the SWMUs have been released into the environment. The overall problem statement developed for the DQO process is as follows:

> Hazardous substances that have been contained in, or passed through, the BGOU SWMUs may have been released to surface water or into surrounding soil or are contained in burial cell materials. These substances may have infiltrated into groundwater below the unit and been transported through subsurface pathways. The nature and extent of contamination have been adequately defined for some SWMUs, and risk assessments have been prepared. For others, the nature and extent of contamination have not been adequately defined to assess whether potential contaminants pose unacceptable risks to human health and the environment at the SWMUs and at downgradient exposure points. Data gaps should be identified, and "closed," so that a comprehensive RI/FS report can be prepared for the eight SWMUs within the BGOU.

The subsequent six steps in the process were completed in accordance with the above-referenced guidance (EPA 1993) and are listed below:

- Decisions to be made
- Identification of inputs to the decisions
- Definition of the boundaries of the study
- Development of a decision rule
- Development of uncertainty constraints
- Optimization of the design for obtaining data

A conceptual site model has been developed and is demonstrated in Figure 1.2. Figure 1.3 shows the DQO process chart. The seven steps of the DQO process have been completed and a set of decision rules and questions to be answered to complete the DQO process is provided in Table 1.1. Table 1.1 states the goals and outlines the decision rules, evaluation methods, and data needs that will determine the final action undertaken at the BGOU SWMUs.

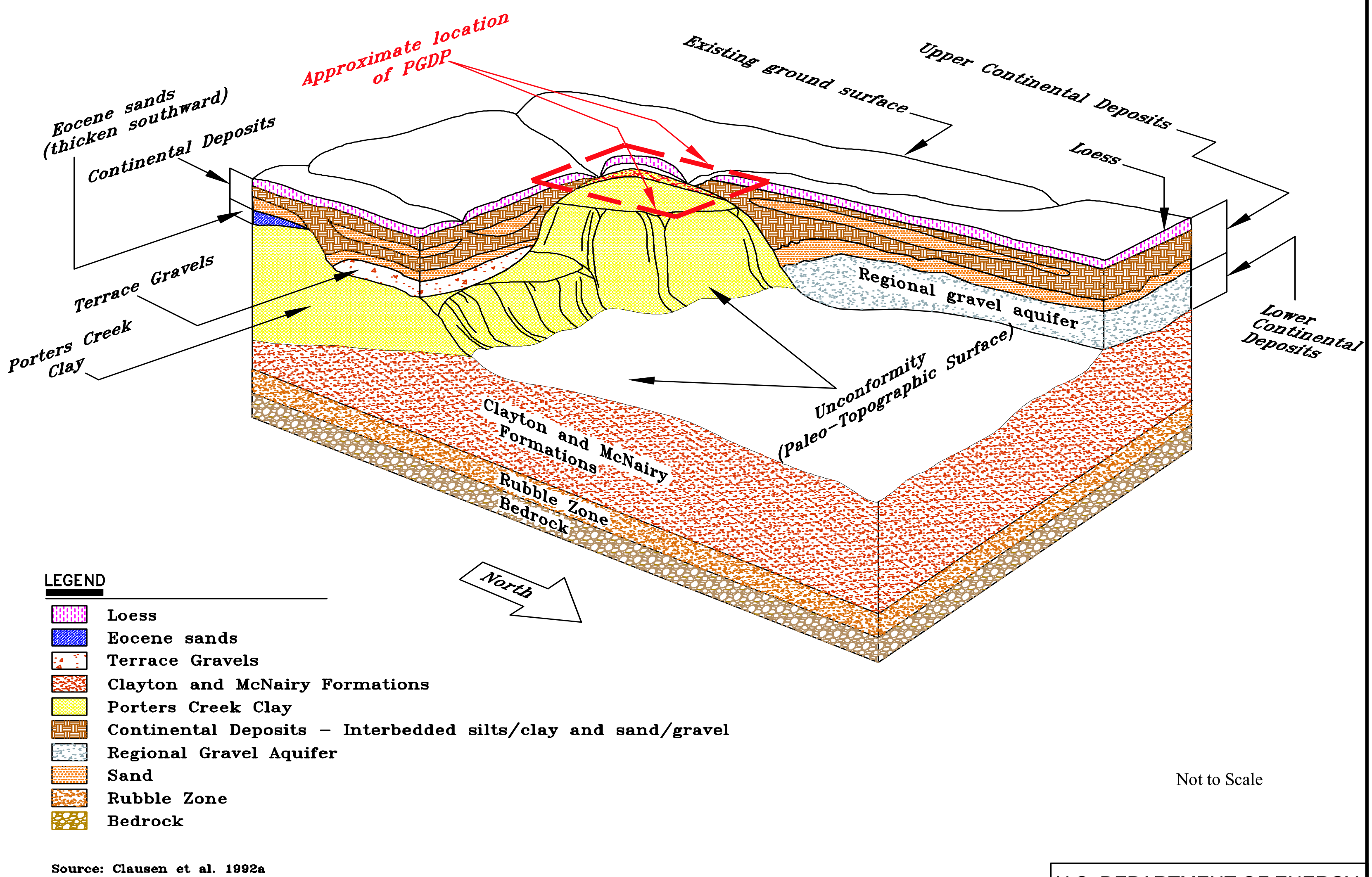

Figure 1.2. Conceptual Model of the Stratigraphy in the Vicinity of PGDP

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DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

PADUCAH Remediation Services
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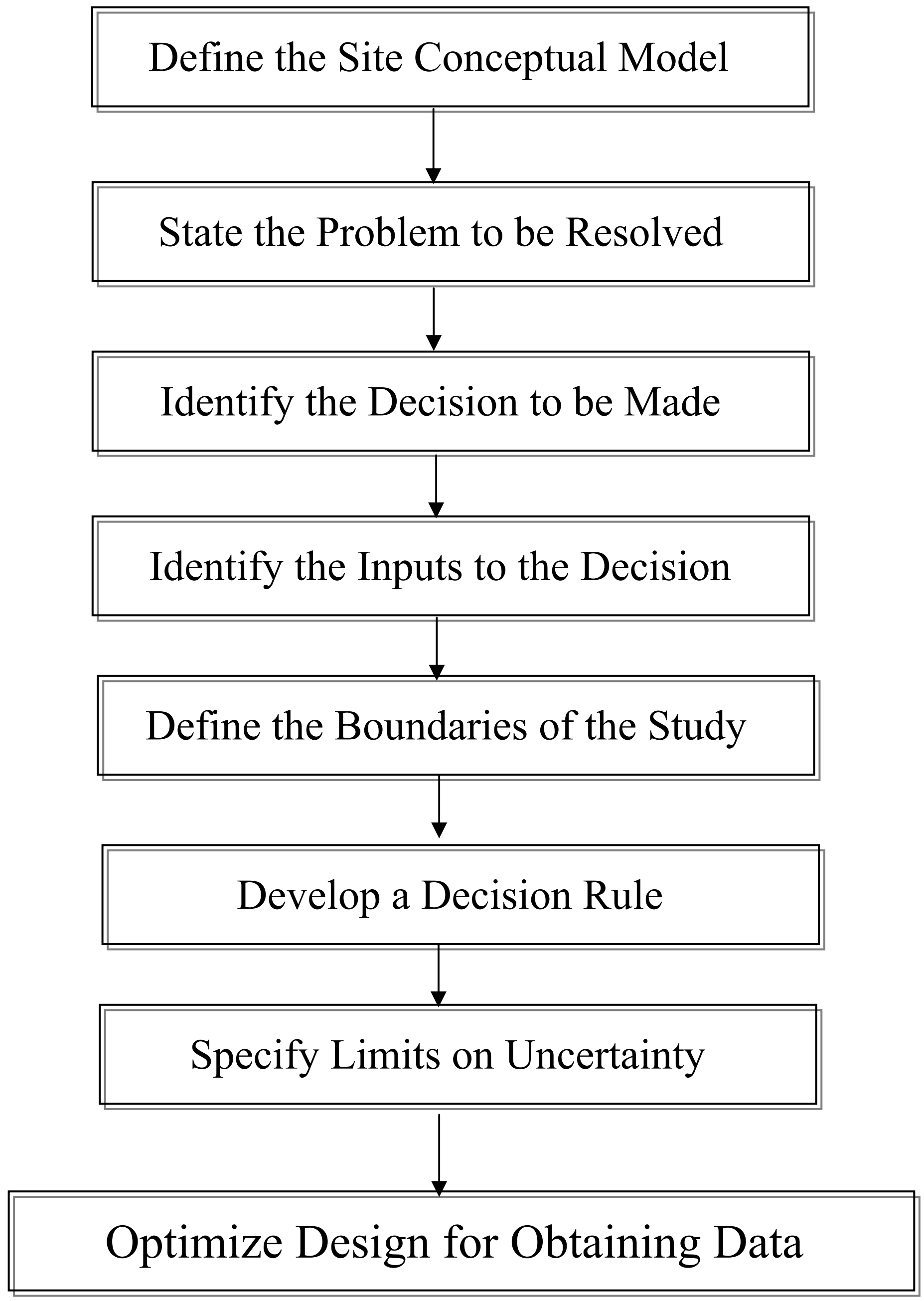

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Figure 1.3. DQO Process Chart

1.4 OBSERVATIONAL APPROACH

The Observational Approach (OA) is a method for identifying and managing uncertainties. The OA emphasizes determining what to do next by evaluating existing information and iterating between collecting new data and taking further action. The name “observational approach” is derived from observing parameters during implementation. OA should be encouraged in situations where the uncertainty is large, the vision of what is expected or required is poor, and the cost of obtaining more certainty is very high.

The philosophy of OA, when applied to waste site remediation, is that a remedial action can be expedited. The approach provides a logical decision framework through which planning, design, and implementation of remedial actions can proceed with increased confidence. OA incorporates the concepts of data sufficiency, identification of reasonable deviations, preparation of contingency plans, observation of the systems for deviations, and implementation of the contingency plans. Determinations of performance measures and the quality of new data are completed as the steps are implemented.

The iterative steps of site characterization, developing and refining a site conceptual model, and identifying uncertainties in the conceptual model are similar to traditional approaches. The concept of addressing uncertainties as reasonable deviations is unique to OA and offers a qualitative description of data sufficiency for proceeding with site remediation.

To deal with uncertainties identified in the BGOU, OA has been used to design the sampling strategy for the BGOU RI/FS. The key concepts are as follows:

- The RI strategy is based on a specified “most probable site condition,” which, for the BGOU RI/FS, assumes that contamination is potentially adversely impacting human health and welfare or an impact on the environment has occurred.

- Reasonable deviations from the most probable site condition are identified. The reasonable deviation for the BGOU RI/FS is that no contamination is adversely impacting human health and welfare or the environment. Site conditions should not differ significantly from the postulated conditions shown in the conceptual models.

- Site assessment factors are identified for observation to detect contamination. These factors include sensory observation of contamination (sight and smell), field screening with portable instruments, geophysical surveys, historical data evaluation, and laboratory analysis of samples.

- The Field Sampling Plan (FSP) discussed in Chapter 9 of this document represents the contingency plan to deal with deviations from the most probable site conditions. A contingency plan that incorporates regulatory approval will be used.

Table 1.1 Decision Rules, Evaluation Methods, and Data Needs for BGOU

GOAL 1: CHARACTERIZE NATURE OF SOURCE ZONE

Decisions and questions

1-1: What are the suspected contaminants?
1-2: What are the plant processes that could have contributed to the contamination? When and over what duration did releases occur?
1-3: What are the concentrations and activities at the source?
1-4: What is the area and volume of the source zone?
1-5: What are the chemical and physical properties of associated material at the source areas?

Decision rule	Evaluation method	Data needs
D1a: If the concentration of analytes found in the source zone could result in a cumulative excess lifetime cancer risk greater than 1×10^{-6} or a cumulative Hazard Index greater than 1 through contact with contaminated media, **or** if the concentration of analytes in the source zone could result in detrimental impacts to nonhuman receptors through contact with contaminated media as indicated by exceeding ecological screening criteria, **and** if the concentrations of analytes in the source zone are greater than those expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise pursue a "no further action" decision (see D1b and D1c).	<u>Screening</u> Quantitative comparisons by medium between maximum detected concentrations of analytes in the source zone and preliminary remediation goals (PRGs) and background concentrations Quantitative comparison by medium between maximum detected concentrations of analytes and nonhuman receptor benchmarks <u>Baseline</u> Completion of baseline human health risk assessment (BHHRA) and screening-level ecological risk assessment (SERA)	Results of previous investigations and reports to target sampling locations and analytical requirements Sampling data from each medium Site use and activity history Procedures and methods for human health and ecological risk assessments of source units
D1b: If concentrations of analytes found in the source zone exceed applicable or relevant and appropriate requirements (ARARs), then evaluate actions that will bring contamination within the source zone into compliance with ARARs; seek an ARAR waiver (such as technical impracticability, inconsistent application of state standards, interim measure, greater risk to human health and the environment, equivalent standard of performance) in accordance with EPA guidance; or propose/obtain alternative standards.	Quantitative comparison by medium between analyte concentrations and ARARs	Results of previous investigations and reports to target sampling locations and analytical requirements Sampling data from each medium Site use and activity history List of chemical-specific ARARs Procedures and methods for performing comparisons

Table 1.1 Decision Rules, Evaluation Methods, and Data Needs for BGOU (continued)

GOAL 1: CHARACTERIZE NATURE OF SOURCE ZONE (continued)		
D1c: If contaminants found at the site are known to transform or degrade into chemicals that could lead to increased risks to human health or the environment or into chemicals for which there are ARARs, **and** if the concentrations of these contaminants could result in risks greater than those defined in D1a or concentrations greater than ARARs, then evaluate actions that will mitigate potential future risk or obtain compliance with ARARs; seek an ARAR waiver (such as technical impracticability, inconsistent application of state standards, interim measure, greater risk to human health and the environment, equivalent standard of performance) in accordance with EPA guidance; or propose/obtain alternative standards.	Completion of a BHHRA that considers transformation and degradation of contaminants found in the source zone Quantitative comparison by medium between analyte concentrations and ARARs	Results of previous investigations and reports to target sampling locations and analytical requirements Sampling data from each medium Site use and activity history Analyte degradation or transformation paths List of chemical-specific ARARs Geochemical and biological parameters that could affect chemical degradation and transformation Procedures and methods for human health and ecological risk assessments and comparison with ARARs

Table 1.1 Decision Rules, Evaluation Methods, and Data Needs for BGOU (continued)

GOAL 2: DEFINE EXTENT OF SOURCE ZONE AND CONTAMINATION IN SOIL AND OTHER SECONDARY SOURCES AT ALL UNITS

Decisions and questions

2-1: What are the past, current, and potential future migratory paths?
2-2: What are the past, current, and potential future release mechanisms?
2-3: What are the contaminant concentrations or activity gradients?
2-4: What is the vertical and lateral extent of contamination?
2-5: What is the relationship of the UCRS gradient to the source, to surface water bodies, and to the RGA?

Decision rule	Evaluation method	Data needs
D2a: If secondary contamination sources are found, **and** if the concentration of analytes within the secondary contamination source is found to potentially result in a cumulative excess lifetime cancer risk greater than 1×10^{-6} or a cumulative Hazard Index greater than 1 through contact with contaminated media at the unit, **and** if the concentrations of analytes are greater than those expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise, do not consider secondary contamination sources when making remedial decisions for the unit.	<u>Screening</u> Quantitative comparisons by medium between maximum detected concentrations of analytes and PRGs and background concentrations Quantitative comparison by medium between maximum detected concentrations of analytes and nonhuman receptor benchmark Comparison between concentrations of trichloro-ethene (TCE) in groundwater and analytical limits set for TCE in detection of secondary contamination sources <u>Baseline</u> Completion of BHHRA and SERA	Results of previous investigations and reports to target sampling locations and analytical requirements Sampling data from UCRS groundwater and potential RGA groundwater if contamination is detected in shallow groundwater Analytical limits for identification of secondary contamination sources Subsurface characterization information, including aquifer properties, stratigraphy, and horizontal and vertical conductivities

Table 1.1 Decision Rules, Evaluation Methods, and Data Needs for BGOU (continued)

GOAL 3: DETERMINE SURFACE AND SUBSURFACE TRANSPORT MECHANISMS AND PATHWAYS

Decisions and questions

3-1: What are the contaminant migration trends?
3-2: To what area is the dissolved-phase plume migrating?
3-3: What are the effects of underground utilities and plant operations on migration pathways including ditches?
3-4: What is the role of the UCRS in contaminant transport?
3-5: What are the physical and chemical properties of the formations and subsurface matrices?

Decision rule	Evaluation method	Data needs
D3a: If contaminants are found in the source zone, **or** if secondary contamination sources are found, **and** if these contaminants are found to be migrating or may migrate from the source zone or from secondary contamination sources at concentrations that may potentially result in a cumulative excess lifetime cancer risk greater than 1×10^{-6} or a cumulative Hazard Index greater than 1 through use of contaminated media at downgradient points of exposure, **and** the concentrations of analytes are greater than those expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise, do not consider risk posed by migratory pathways when evaluating remedial alternatives for the unit (see D3b).	<u>Screening</u> Quantitative comparisons by medium between modeled contaminant concentrations and PRGs and background concentrations <u>Baseline</u> Completion of a BHHRA for exposure points located away from the unit to which contaminants may migrate	Results of analyses performed under D1a and D2a Procedures and methods for human health and ecological risk assessment of source units Current and expected land-use patterns Results of models (e.g., MEPAS, RESRAD, SESOIL) that can predict future groundwater or surface water contaminant concentrations at exposure points Modeling parameters, including groundwater flow, horizontal and vertical hydraulic conductivity, chemical parameters, mineralogy, oxidation-reduction potential, and porosity Determination of properties of UCRS and RGA groundwater that will significantly affect uranium transport and barium, iron, magnesium, sodium, potassium, chloride, phosphate, bicarbonate, alkalinity, fluoride, and dissolved silica

Table 1.1 Decision Rules, Evaluation Methods, and Data Needs for BGOU (continued)

GOAL 3: DETERMINE SURFACE AND SUBSURFACE TRANSPORT MECHANISMS AND PATHWAYS (continued)		
D3b: If contaminants are found in the source zone, **or** if secondary contamination sources are found, **and** if these contaminants are found to be migrating or may migrate from the source zone or from the secondary contamination source at concentrations that exceed ARARs, then evaluate actions that will bring migratory concentrations into compliance with ARARs; seek an ARAR waiver (such as technical impracticability, inconsistent application of state standards, interim measure, greater risk to human health and the environment, equivalent standard of performance) in accordance with EPA guidance; or propose/obtain alternative standards; otherwise, do not consider ARARs when examining migratory pathways during the evaluation of remedial actions (see D3a).	Quantitative comparison by medium between modeled analyte concentrations at downgradient exposure points and ARARs	Results of analyses performed under D1b List of chemical-specific ARARs Current and expected land-use patterns Results of models (e.g., MEPAS, RESRAD, SESOIL) that can predict future groundwater or surface water contaminant concentrations at exposure points (Geochemical equilibria will be addressed in the RI report.) Modeling parameters, including groundwater flow, horizontal and vertical conductivity, chemical parameters, mineralogy, oxidation-reduction potential, and porosity

Table 1.1 Decision Rules, Evaluation Methods, and Data Needs for BGOU (continued)

GOAL 4: SUPPORT EVALUATION OF REMEDIAL ALTERNATIVES

Decisions and questions

4-1: What are the possible remedial technologies applicable for this unit?
4-2: What are the physical and chemical properties of media to be remediated?
4-3: Are cultural impediments present?
4-4: What is the extent of contamination (geologic limitations presented by the source zone or secondary contamination source)?
4-5: What would be the impact of action on and by other sources?
4-6: What would the impact of an action at the source be on the integrator units?
4-7: What are stakeholders' perceptions of contamination at or migrating from source zone or secondary contamination sources?

Decision rule	Evaluation method	Data needs
D4a: If Decision D1a, D1b, D1c, D2a, D3a, or D3b indicate that response actions are needed, then evaluate response actions to mitigate risk in the source zone.	Use of results of BHHRA and SERA to determine if action is needed Use of results of comparison of contaminant concentrations to ARARs to determine if action is needed Qualitative (or quantitative) assessment of decrease or increase in risk to human health and the environment as a result of implementation Evaluation of ARARs Evaluation of existing risk management procedures or activities currently being conducted at the site	Data listed for D1a, D1b, D1c, D2a, D3a, and D3b Methods for qualitative (or quantitative) analyses of decrease or increase in risk to human health and the environment as a result of implementation Additional physical parameters, including compaction, grain size, cation exchange, thermodynamic conductivity, dielectric constants, chemical oxygen demand, pH, and moisture content of soils Total dissolved solids in groundwater List of ARARs

MEPAS = Multimedia Environmental Pollutant Assessment System
RESRAD = Residual Radioactive Materials
SESOIL = Seasonal Soil Compartment Model
pH = negative logarithm of the hydrogen-ion concentration

2. PROJECT ORGANIZATION AND MANAGEMENT PLAN

This section presents the project organization for this BGOU RI/FS. The topics addressed in this section include project organization, project coordination, and project schedule.

2.1 PROJECT ORGANIZATION, RESPONSIBILITIES, AND STAFFING

The organization chart shown in Figure 2.1 outlines the management structure that will be used for implementing the BGOU RI/FS. The responsibilities of key personnel are described in the following paragraphs.

2.1.1 DOE Project Manager

The DOE Project Manager will provide technical and management oversight for DOE for the BGOU RI/FS. This individual also will be the primary interface between the EPA and KDEP regulators and the DOE Prime Contractor.

2.1.2 DOE Prime Contractor ER Manager

The DOE Prime Contractor ER Manager will have overall programmatic responsibility for the Contractor for the technical, financial, and scheduling of matters related to the BGOU RI/FS. This individual will interface with DOE and the regulators, as appropriate.

2.1.3 DOE Prime Contractor Data Manager

The DOE Prime Contractor Data Manager is responsible for long-term storage of project data and for transmitting data to external agencies according to the Paducah Site Data Management Plan (DOE 1998a) and the Paducah Data Management Policy. The DOE Prime Contractor Data Manager ensures compliance to policies and procedures relating to data management with respect to the project.

2.1.4 DOE Prime Contractor Sample Manager

The DOE Prime Contractor Sample Manager is responsible for contracting any fixed-base laboratory utilized during the BGOU sampling activities. The DOE Prime Contractor Sample Manager also provides coordination for sample shipment to the laboratory, reviews the contractual screening section of data assessment packages, and transmits data packages to the Paducah Document Management Center (DMC).

2.1.5 DOE Prime Contractor RI Project Manager

The RI Project Manager will have overall responsibility for implementing the assessment, including all plans and field activities conducted as part of the RI/FS, including monitoring the work plan implementation, including sampling and waste management activities. This individual will serve as the RI technical lead and the principal point of contact. The RI Project Manager will track the project budget and schedules and will delegate specific responsibilities to project team members. This individual also is responsible for the preparation of any field change orders.

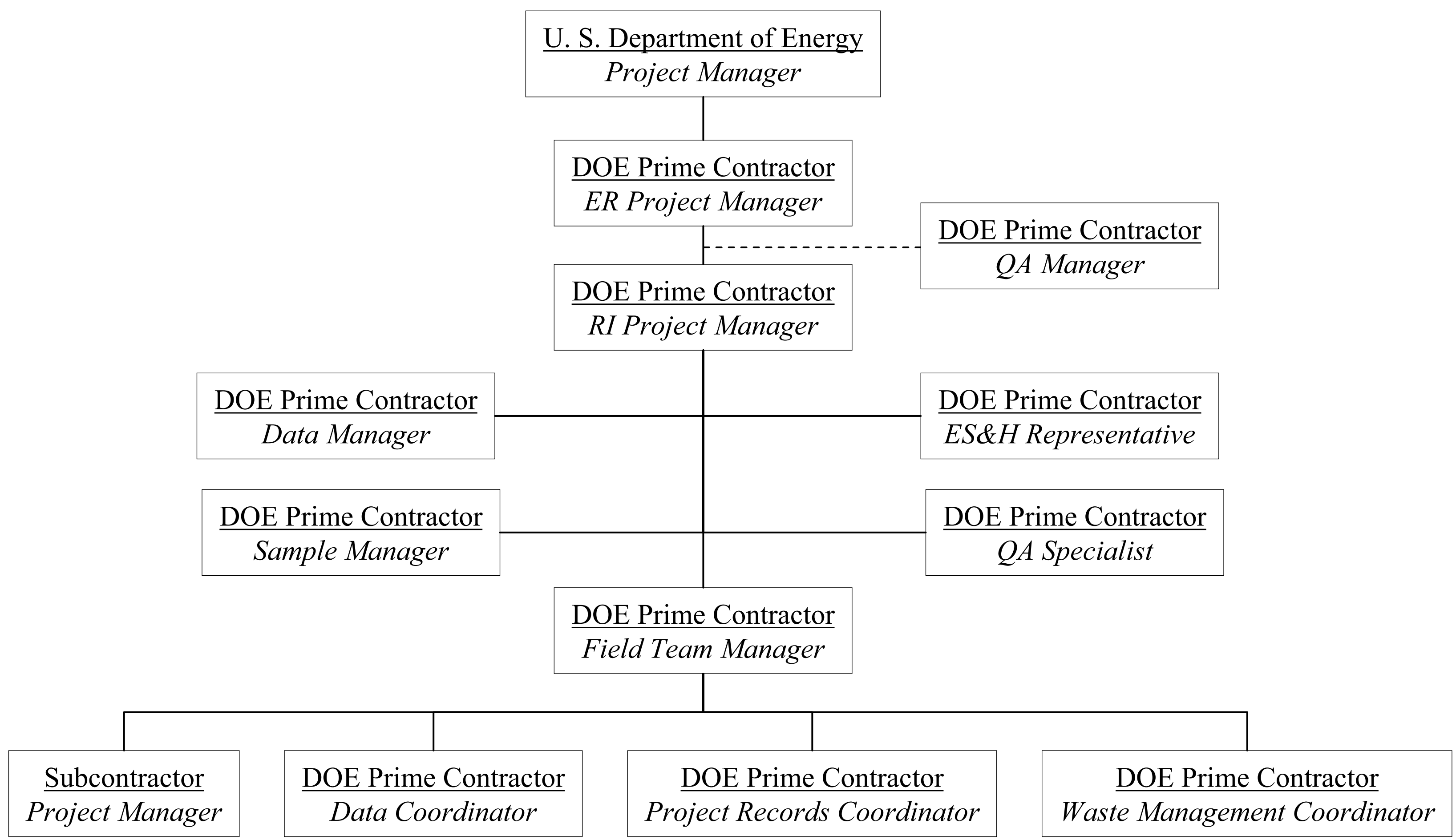

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Figure 2.1. BGOU Project Organizational Chart

2.1.6 DOE Prime Contractor ES&H Representative

The Environment, Safety, and Health (ES&H), Representative oversees that health and safety procedures designed to protect project personnel are maintained throughout the field effort for this project. This individual will ensure the implementation of an Integrated Safety Management System (ISMS) for all aspects of the assessment. ISMS is dedicated to the concept that all accidents are preventable. Accordingly, the DOE Prime Contractor, the RI Team, and all subcontractors will be expected to achieve and sustain "Zero-Accident Performance" through continuous improvement practices. "Zero-Accident Performance" includes zero unpermitted discharges or releases with respect to protection of the environment.

2.1.7 DOE Prime Contractor QA Specialist

The QA Specialist will provide oversight and approval for the project. This individual also will conduct audits and surveillances and approve any field changes that may impact project quality.

2.1.8 DOE Prime Contractor Field Team Manager

The Field Team Manager (FTM) provides technical oversight for all field team activities during the investigation.

2.1.9 DOE Prime Contractor Project Records Coordinator

The Project Records Coordinator will be responsible for all activities relating to identification, acquisition, classification, indexing, and storage of project records related to the investigation. The project records will include data documentation materials, plans, procedures, and all project file requirements.

2.1.10 DOE Prime Contractor Waste Management Coordinator

The Waste Management Coordinator (WMC) will be responsible for ensuring adherence to the Waste Management Plan (WMP) that is described in Chapter 13 of this document and for documenting and tracking field-related activities, including waste generation and handling, waste characterization sampling, waste transfer, and waste labeling. The WMC will perform the majority of waste handling field activities.

2.1.11 DOE Prime Contractor Sample Management/Data Coordinator

The Sample Management/Data Coordinator will be responsible for the coordination of all investigation-sampling activities, including coordination with the DOE Prime Contractor Sample Management Office (SMO). This individual will ensure all quality control (QC) sampling requirements are met, chain-of-custody forms are properly generated, and that compliance with off-site shipping requirements is achieved. The Sample Management/Data Coordinator also will be responsible for managing data generated during the investigation in accordance with the Data Management Implementation Plan (DMIP) described in Chapter 12 of this document.

2.2 PROJECT COORDINATION

Coordination and liaison between the DOE Prime Contractor and the Subcontractor personnel will occur at various levels and among personnel appropriate to each level. Routine reports, such as monthly reports, will be prepared by the Subcontractor Project Manager and then submitted to the DOE Prime

Contractor RI Project Manager, Contracts Procurement Office, Contracts Coordinator, or other designated recipient.

2.3 PROJECT TASKS AND IMPLEMENTATION PLAN

The RI/FS Implementation Plan for this project is shown in Figure 2.2. This plan represents a logical approach to implementation of the project, as described below.

1. The first step in this project was preparation of the RI/FS Work Plan. As part of this task, existing data were evaluated to develop the conceptual models (Clausen et al. 1992). In turn, the conceptual models were used to identify site unknowns, and a sampling strategy was designed to meet the FFA requirements and to address these unknowns.

2. Implementation of the work plan will begin with procurement of subcontract services, such as drilling and surveying.

3. Field activities will consist of several discrete activities, as outlined in this work plan, including drilling, surveying, sampling, sample handling, decontamination, waste management, and documentation. In addition, ES&H and field QA coordination will occur concurrently with the other activities.

4. Field and laboratory data will be reduced, validated or verified, and assessed. Data validation will be conducted by an independent third party and will be initiated once the first sample delivery group of data has been received and checked for completeness. Each of these steps will be handled separately and will follow prescribed procedures to ensure that defensible data are obtained. The data will be formatted for incorporation into the PGDP database and archived for future use.

5. Technical exchange meetings will be conducted among personnel from EPA, KDEP, DOE, and DOE Prime Contractor to evaluate the existing data (from the RI only) and determine future actions. If additional data are considered necessary to support the project objectives, additional data points will be identified and incorporated into the FSP.

6. Non-field-related tasks that also will be performed during the RI/FS include coordination of community relations during the project, preparation of a BRA, implementation of the QA program, evaluation of remedial technologies, and implementation of treatability studies.

7. An RI/FS report will be prepared and issued after samples and data have been processed.

8. Project management, tracking, and reporting will be conducted concurrently with all activities.

2.4 PROJECT SCHEDULE

This Section 2.4 and Figure 2.3 provide a schedule of the activities proposed for the BGOU RI/FS Work Plan implementation. These schedules are estimates for planning, consistent with schedules set forth in the approved SMP. These schedules are not enforceable, but are included, herein, for information purposes only. The FFA sets forth enforceable schedules for the BGOU. The following assumptions were used to develop this schedule. Delays in or changes to any of these assumptions could result in overall scope delay.

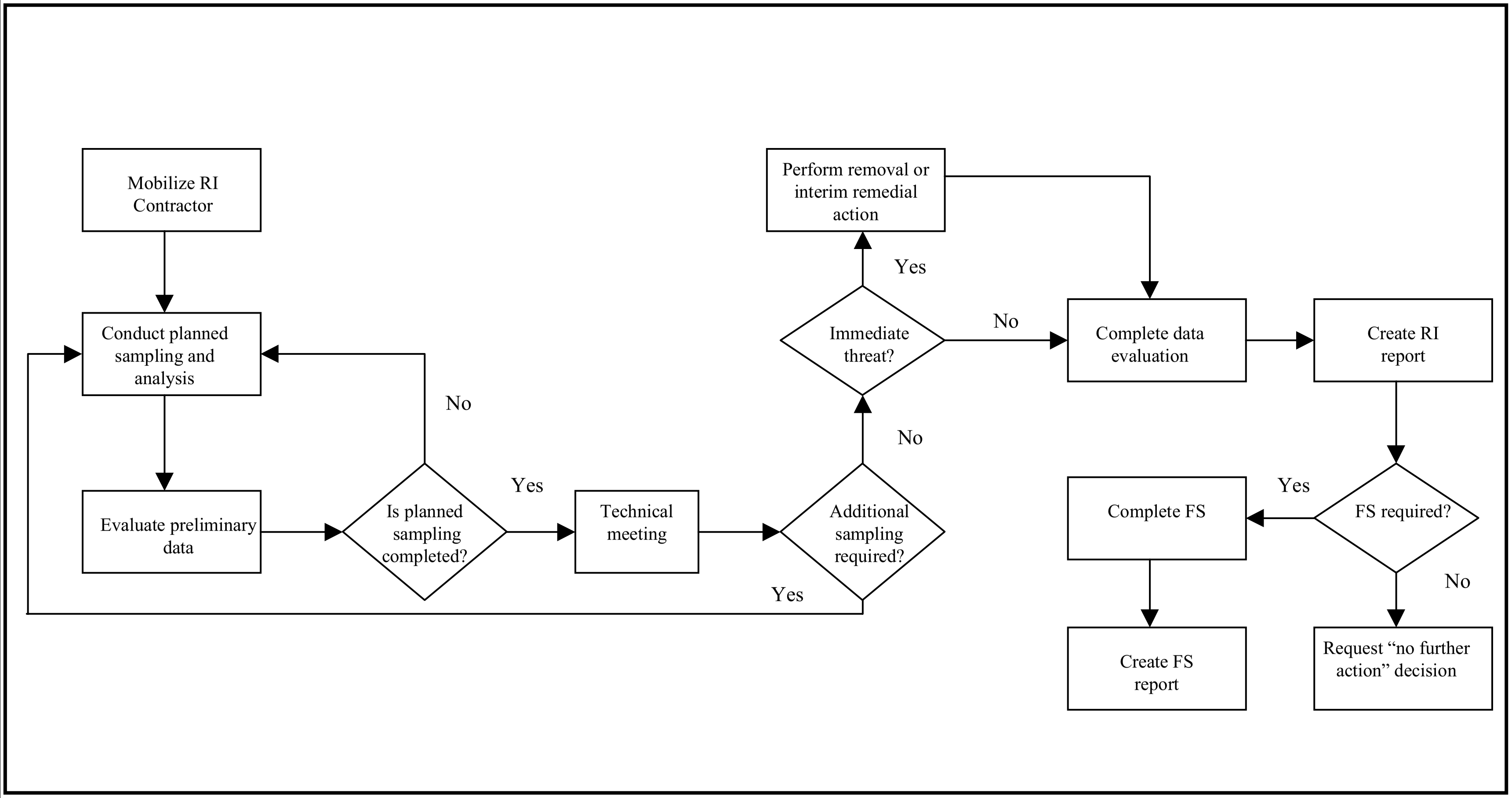

Figure 2.2. BGOU RI/FS Process Flowchart Showing Major Activities and Decision Points

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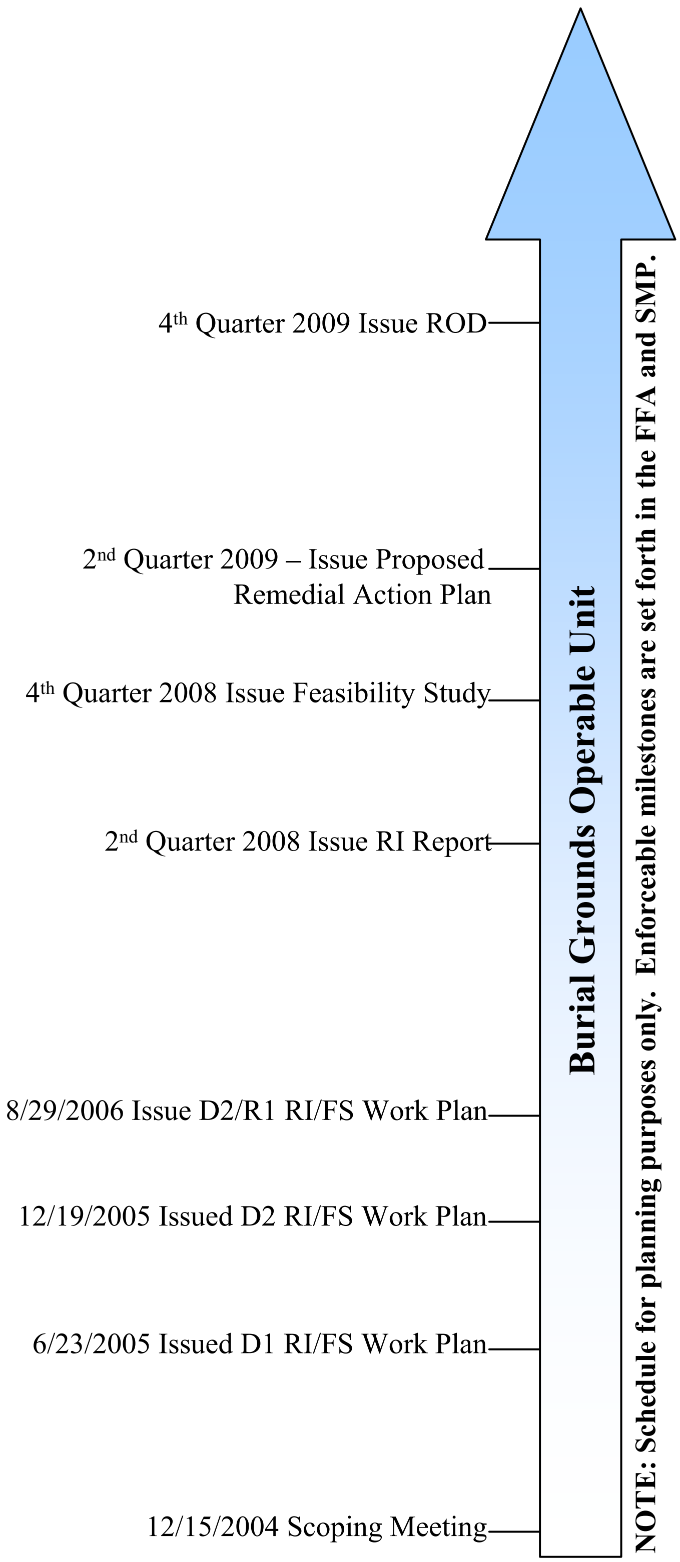

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Figure 2.3 BGOU RI/FS Schedule.

- EPA and KDEP will approve the D2/R1 BGOU RI/FS Work Plan by September 29, 2006.

- The DOE Prime Contractor will initiate the procurement process to allow a Notice-to-Proceed, with field activities to be issued to the Subcontractor in Fiscal Year 2006 in accordance with current funding profiles.

- The schedule, as shown, does not account for schedule delays resulting from inclement weather conditions, such as rain or snow.

- Laboratory analysis reports for individual data packages will be received within 60 days of the completion of all samples contained in that data package.

- Data verification, validation, and assessment activities for individual data packages will be available within 60 days of receipt of the laboratory analysis reports for the data package.

- If additional sampling is required, then the completion date of subsequent tasks will be delayed.

2.5 RI/FS WORK PLAN ACTIVITIES

2.5.1 Security Plan

A security plan will be written for the BGOU RI/FS fieldwork. This plan will address security issues/concerns for the project, while working inside the security fence at PGDP. This classification status could result in restricting access during RI field activities, as well as additional reviews and oversight. The security plan will be completed prior to field mobilization. All field team members will be required to read the plan prior to participating in BGOU field activities.

2.5.2 Field Preparation Activities

The FTM will ensure that a field planning meeting occurs before the internal field review and before work begins at the site so that all involved personnel, including employees of the subcontractors, DOE Prime Contractor, and DOE, as appropriate, will be informed of the requirements of the fieldwork associated with the project.

In addition, an internal field review will be held in accordance with DOE prime contractor procedures. Any contingency items identified during the review must be completed prior to the DOE Prime Contractor providing a notice to proceed to the Subcontractor for initiating fieldwork activities.

During the RI field activities and immediately after the RI field effort, a project status meeting will be held. Personnel invited to attend the meetings will include the FTM and a representative from the DOE Prime Contractor and DOE. At a minimum, the Subcontractor Project Manager and DOE Prime Contractor RI Project Manager will attend. The meeting will be held at the field support facilities or at another convenient location.

2.5.3 Establishment of Field Support Facility

The following is general information concerning the setup of a Field Support Facility. The actual layout and location of the facility will be determined based on the facilities provided by PGDP. The Field Support Facility will be located near the SWMUs and will consist of one or more trailers. The facility will support field operations by maintaining areas for sample container preparation, sample preparation, sample storage, operational management, field screening, field vehicle parking, and other support activities as needed. Existing PGDP facilities, such as trailers, parking areas, dressing rooms, and showers, will be used if available.

The operational management area will be used by the FTM for the purpose of supervision and coordination of field activities. This area also will be used for the storage and maintenance of field radios, field monitoring equipment, and ES&H equipment. Other support and field personnel will use this area as necessary.

The sample control area will be used for container preparation, sample storage, sample preparation, and document control. Sample preparation will be conducted in a discrete area that will contain all required equipment and safeguards. The area will be securable to ensure that sample control is maintained. Sample labels, sample tags, and chain-of-custody forms will be kept in this area.

The field equipment storage area will be used to store field supplies and equipment to ensure that the equipment is readily available to the field crews.

One of the decontamination pads at PGDP will be set up to perform drilling rig and sampling equipment decontamination. The use of the decontamination pad will be scheduled with the DOE Prime Contractor before the initiation of fieldwork.

2.5.4 Field Investigation

Activities to be conducted during the field investigation include mobilization, implementation of health and safety procedures, geophysical surveys, soil sampling, groundwater sampling, well installation, and implementation of QA procedures. In addition, surveying activities will be performed to provide horizontal and vertical references for characterizing of locations.

2.5.5 Supporting Activities

Activities supporting the field investigation are discussed in the following chapters:

- Baseline risk assessment—Chapter 6
- Treatability studies—Chapter 7
- FS—Chapter 8
- Field Sampling Plan—Chapter 9
- Environment, safety, and health—Chapter 10
- QA—Chapter 11
- Data and records management—Chapter 12
- Waste management—Chapter 13
- Community relations—Chapter 14

Additionally, the following appendices support the work to be conducted during this RI/FS:

- ARARs—Appendix A
- Statistical Evaluation Methods—Appendix B
- Miscellaneous Forms—Appendix C
- Document Outlines—Appendix D
- Historical Data Summary—Appendix E
- Historical Risk Assessment Summary—Appendix F
- 3-Dimensional Data Visualization—Appendix G

Appendix F, the Historical Risk Assessment Summary contains information for historical perspective only, the information was prepared with information available at the time. Additional information may have become available since its development, therefore, results and conclusions presented within this appendix should be considered information only.

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3. REGULATORY SETTING

The sections that follow provide a condensed version of the regulatory framework for PGDP. The summary in this chapter is intended to provide readers with some general knowledge of the facility and the regulatory protocol that guides environmental management activities at PGDP. Detailed descriptions can be found in the *Site Management Plan, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2004a).

3.1 ADMINISTRATIVE CONSENT ORDER

The Commonwealth of Kentucky, EPA, and DOE entered into the ACO effective November 23, 1988, after the discovery of contamination in residential wells north of PGDP. The ACO is a legally binding agreement for the participating parties that initiated the investigation into the nature and extent of the contamination in these wells. The contaminants are believed to have originated as process-derived wastes or commonly used materials employed during the operational history of PGDP.

The ACO initiated the investigative activities designed to determine the extent and sources of off-site contamination surrounding PGDP. The site investigation (SI) was completed in 1992 under the guidelines of the ACO. The prior requirements of the ACO were superceded by the execution of the FFA, which DOE, EPA, and the Commonwealth of Kentucky signed in 1998.

3.2 ENVIRONMENTAL PROGRAMS

Environmental sampling at PGDP is a multimedia (air, water, soil, sediment, direct radiation, and biota) program of chemical, radiological, and ecological monitoring, and environmental monitoring that consists of two activities: effluent monitoring and environmental surveillance. Although the evaluation and assessment of unplanned releases are addressed in this plan, emergency monitoring and responsibilities for this activity are not included. As part of the ongoing ER activities, SWMUs and AOCs, both on and off DOE property, have been identified. Characterization and/or remediation of these sites will continue pursuant to the CERCLA, and Hazardous and Solid Waste Amendments (HSWA) corrective action conditions of the Resource Conservation and Recovery Act (RCRA) Permit. RCRA and CERCLA requirements are coordinated by DOE, EPA, and the Commonwealth of Kentucky through the FFA, which DOE, EPA, and the Commonwealth of Kentucky signed in 1998.

3.3 RESOURCE CONSERVATION AND RECOVERY ACT

The primary purpose of RCRA is to protect human health and the environment through the proper management of hazardous wastes at operating sites.

RCRA requirements for PGDP are contained in PGDP's Hazardous Waste Management Permit (KY8-890-008-982, originally issued July 1991, reissued September 2004). This permit originally was issued by both the Commonwealth of Kentucky and EPA. EPA's portion of the RCRA permit was limited to the HSWA provisions of RCRA, which include corrective action requirements for SWMUs. Kentucky became authorized in 1996 for corrective actions; therefore, the reissued permit was issued solely by

Kentucky. The RCRA permit contains regulatory provisions for treatment, storage, and disposal units, as well as provisions requiring corrective action for SWMUs.

3.4 CERCLA/NATIONAL PRIORITIES LIST

PGDP was placed on the NPL on May 31, 1994. In accordance with Section 120 of CERCLA, DOE entered into an FFA with EPA and the Commonwealth of Kentucky. The FFA established one set of consistent requirements for achieving comprehensive site remediation in accordance with RCRA and CERCLA, including stakeholder involvement.

Section XVIII of the FFA requires DOE to submit an annual SMP, which details the strategic approach for achieving cleanup under the FFA. The FFA states that the purpose of the SMP is to coordinate and document the potential and selected OUs, including removal actions; define cleanup priorities; identify work activities that will serve as the basis for enforceable timetables and deadlines under the agreement; and establish long-term cleanup goals.

3.5 NATIONAL ENVIRONMENTAL POLICY ACT

The intent of the National Environmental Policy Act (NEPA) is to promote a decision-making process that results in minimization of adverse impacts to human health and the environment. On June 13, 1994, the Secretary of Energy issued a Secretarial Policy (Policy) on NEPA that addresses NEPA requirements for actions taken under CERCLA. Section II.E of the Policy indicates that to facilitate meeting the environmental objectives of CERCLA and respond to concerns of regulators consistent with the procedures of most other federal agencies, DOE hereafter will rely on the CERCLA process for review of actions to be taken under CERCLA and will address NEPA values. DOE CERCLA documents will incorporate NEPA values, such as analysis of cumulative, off-site, ecological, and socio-economic impacts, to the extent practicable.

3.6 INVESTIGATIVE OVERVIEW

This BGOU RI/FS Work Plan defines the additional sampling necessary to obtain sufficient data to complete the risk assessment for the BGOU and initiate the FS. Many of these SWMUs have been investigated previously during an RI. The strategy for this work plan is to identify data gaps and complete characterization of the nature and extent of contamination for each SWMU. The Executive Summary of this document provides a table of results from the data gap analysis.

4. ENVIRONMENTAL SETTING AND SITE CHARACTERIZATION

The sections that follow provide a condensed version of the environmental setting for PGDP. The summary in this chapter is intended to provide readers with knowledge of the facility with an overview of relevant information pertaining to location, demography, geology, hydrogeology, ecology, and climatology. Detailed descriptions can be found in *Integrated Remedial Investigation/Feasibility Study Work Plan for Waste Area Grouping 6 at Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1997a).

4.1 LOCATION AND DESCRIPTION

PGDP is located ~10 miles west of Paducah, Kentucky (population ~31,000), and 3.5 miles south of the Ohio River in the western part of McCracken County (Figure 4.1). The plant is on a 3556-acre DOE site of which 748 acres are within a fenced security area, 689 acres are located outside the security fence, 133 acres are in acquired easements, and the remaining 1986 acres are licensed to the Commonwealth of Kentucky as part of the West Kentucky Wildlife Management Area (WKWMA). Bordering the PGDP reservation to the northeast, between the plant and the Ohio River, is a Tennessee Valley Authority (TVA) reservation on which the Shawnee Steam Plant is located (Figure 4.2).

4.2 DEMOGRAPHY AND LAND USE

PGDP is surrounded by WKWMA and some sparsely populated agricultural lands. The closest communities to the plant are Heath, Grahamville, and Kevil, all of which are located within three miles of DOE reservation boundaries. The closest municipalities are Paducah, Kentucky; Cape Girardeau, Missouri, which is ~40 miles west of the plant; and the cities of Metropolis and Joppa, Illinois, which are located across the Ohio River from PGDP.

Historically, the economy of Western Kentucky has been based on agriculture, although there has been increased industrial development in recent years. PGDP employs ~1800 people, while the TVA Shawnee Steam Plant employs an additional 500 people (Oakes et al. 1987). The total population within a 50-mile radius of PGDP is ~500,000; and ~50,000 people live within ten miles of the plant. The population of McCracken County is estimated to be ~63,000 (Slater and Hall 1992).

In addition to the residential population surrounding the plant, WKWMA draws thousands of visitors each year for recreational purposes. This area is used by visitors, primarily for hunting and fishing, but other activities include horseback riding, hiking, and bird watching. According to WKWMA management, an estimated 5000 fishermen visit the area each year.

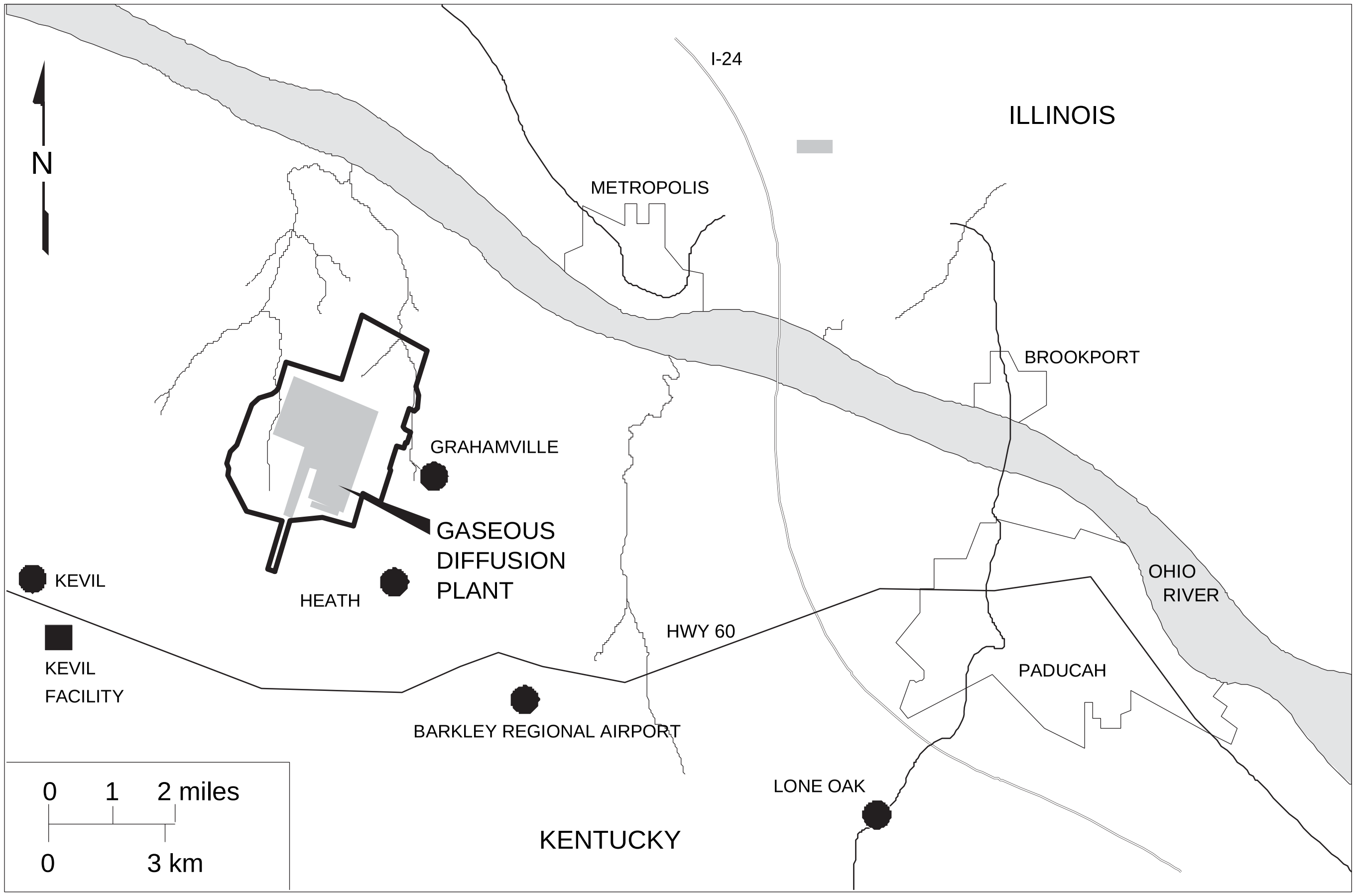

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Figure 4.1. PGDP vicinity map

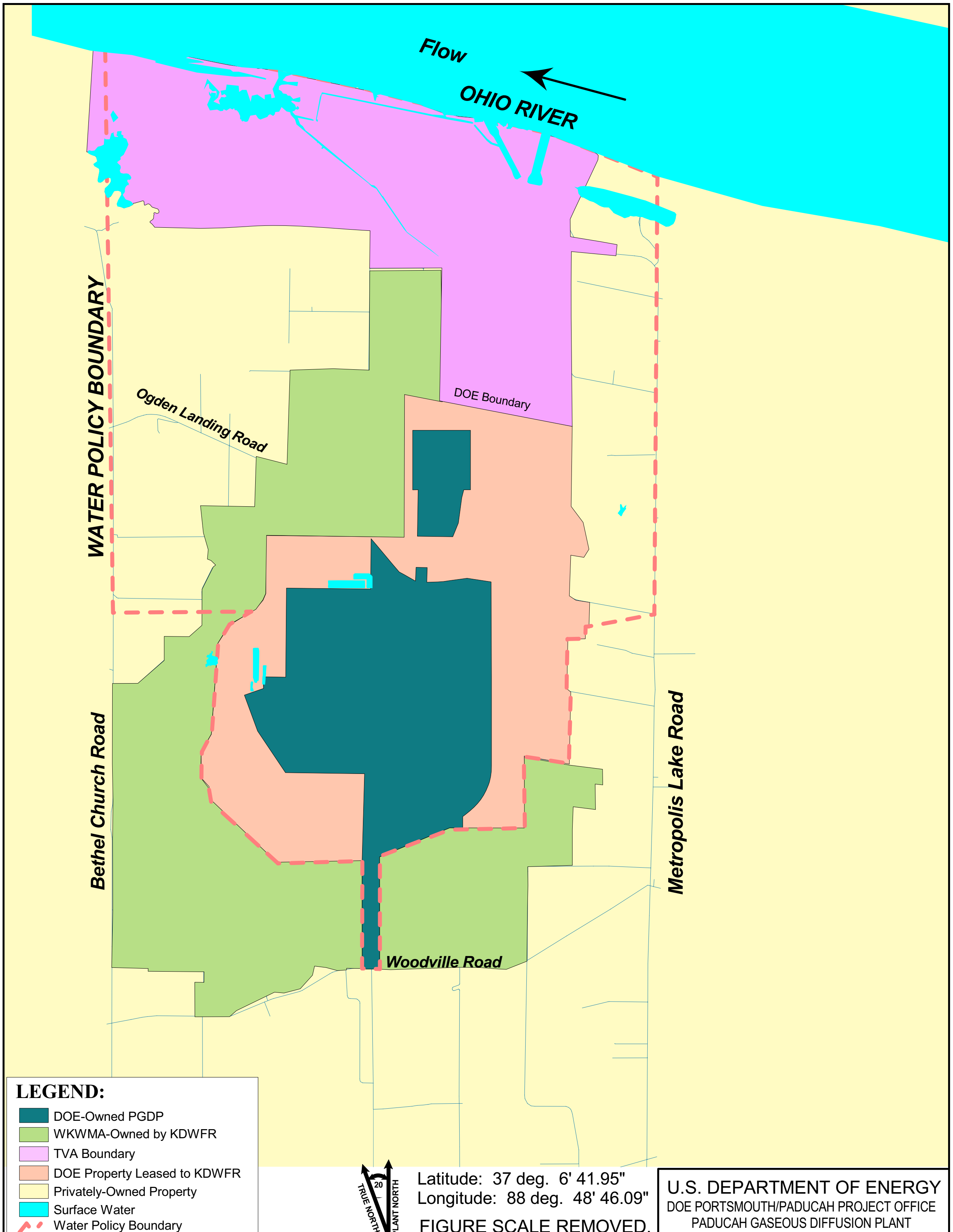

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Figure 4.2. Land Ownership in Proximity to DOE Reservation

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4.3 DESCRIPTION OF PADUCAH GASEOUS DIFFUSION PLANT

PGDP is a DOE-owned uranium enrichment plant consisting of a diffusion cascade system and associated support facilities. Effective July 1, 1993, DOE leased the plant production operations facilities to the United States Enrichment Corporation, which, in turn, contracted with Lockheed Martin Utility Systems to perform operations and maintenance activities. Construction of the plant began in 1951, and operation was initiated in 1952. The plant enriches uranium-235 (^{235}U), the second most abundant isotope in naturally occurring uranium, from much less than 1% (its natural abundance) to almost 5%. Enrichment of ^{235}U is necessary because the most abundant isotope of uranium, ^{238}U (>99%), is not a fissile material. The enrichment process requires extensive support facilities; some of the facilities currently active at PGDP include a steam plant, four major electrical switchyards, four sets of cooling towers, a building for chemical cleaning and decontamination, a water treatment plant, maintenance facilities, and laboratory facilities. Several inactive facilities also are located on the plant site.

From 1953 until 1977, most of the uranium hexafluoride (UF_6) used by PGDP was produced from feedstock in the PGDP feed plant (C-410 building), which was designed to process both natural uranium and uranium from reactor tails. The reactor tails uranium included uranium that had been returned for re-enrichment from the plutonium production reactors at the DOE Hanford and Savannah River plants. Those tails received after 1975, however, were placed in storage rather than being processed. As a result of nuclear reactions in the plutonium production reactors, the reactor tails contained technetium-99 (^{99}Tc) before they entered PGDP and are believed to be the sole source of ^{99}Tc released to the environment at PGDP. Since 1977, PGDP has been supplied with UF_6 feedstock from commercial converters, such as Allied Signal in Metropolis, Illinois, and from foreign sources.

Although various hazardous, nonhazardous, and radioactive wastes resulting from ongoing operations have been generated and disposed of at PGDP, ^{99}Tc, polychlorinated biphenyls (PCBs), and TCE have been determined to be the most commonly occurring environmental COCs at the facility. Since the plant's construction, TCE had been used as a cleaning solvent. The use of TCE as a degreaser ceased on July 1, 1993. PCBs were used extensively as an insulating, nonflammable, thermally conductive fluid in electrical capacitors and transformers at PGDP. PCB oils also were used as flame retardants on the gaskets of diffusion cascades and other sections of the plant and as hydraulic fluid.

4.4 REGIONAL GEOLOGIC SETTING

PGDP is located in the Jackson Purchase region of Western Kentucky, which represents the northern tip of the Mississippi Embayment portion of the Coastal Plain Province. The Jackson Purchase region is an area of land that includes all of Kentucky west of the Tennessee River. The stratigraphic sequence in the region consists of Cretaceous, Tertiary, and Quaternary sediments unconformably overlying Paleozoic bedrock.

4.5 GEOLOGY OF PGDP

Information presented herein regarding the geologic setting at PGDP was derived from the *Report of the Paducah Gaseous Diffusion Plant Groundwater Investigation Phase III* (Clausen et al. 1992). Subsequent sections will briefly discuss the formations represented in Figure 1.3 to acquaint the reader with PGDP geology and provide a framework for the development of the conceptual model for each of the SWMUs included in the RI/FS.

4.5.1 Bedrock

The entire PGDP area is underlain by Mississippian carbonates, consisting of a dark gray limestone with some interbedded chert and shale.

4.5.2 Rubble Zone

A rubble zone of chert gravel is commonly encountered in soil borings at the top of the bedrock. The age and continuity of the rubble zone remain undefined.

4.5.3 McNairy Formation

The McNairy Formation consists of Upper Cretaceous sediments of grayish-white to dark gray micaceous clay with interbedded gray to yellow to reddish-brown, very fine- to medium-grained sand. A basal sand member also is present at PGDP.

4.5.4 Porters Creek Clay/Porters Creek Terrace

The Paleocene Porters Creek Clay occurs in the southern portions of the site and consists of dark gray to black clay with varying amounts of silt and fine-grained micaceous, commonly glauconitic, sand. The Porters Creek Clay subcrops along a buried terrace slope that extends east–west across the site. Erosion into the Paleocene Porters Creek Clay, after the deposition of overlying Eocene through Pleistocene sediments (terrace gravels and Eocene sands), resulted in an important hydrogeologic feature known as the Porters Creek terrace. The Porters Creek terrace lies immediately southwest of PGDP; the terrace slope extends northward toward the southern boundary of the PGDP fenced security area. The Porters Creek terrace is hydrogeologically important because it is believed to mark the southern extent of the lower continental deposits and the RGA, and it forms the aquitard below the RGA along the slope of the Porters Creek terrace and for some distance northward.

4.5.5 Eocene Sands

Eocene sands are found south of PGDP above the Porters Creek Clay. These sands are believed to be composed of undifferentiated sediments of the Claiborne Group and Wilcox Formation. Olive (1966) describes the sands as predominantly clear quartz with minor amounts of gray quartz and chert with interbedded and interlensing silts and clays. The Eocene sands thicken south of PGDP and may serve as a significant water-bearing unit south of the plant.

4.5.6 Continental Deposits

Continental sediments [Pliocene (?) to Pleistocene—a question mark indicates uncertain age] unconformably overlie the Cretaceous through Eocene strata throughout the area. These continental sediments were deposited on an irregular erosional surface exhibiting steps or terraces. The thicker sequences represent a valley fill that exhibits a thick, fining-upward sequence. The continental sediments have been divided into the two distinct facies described as follows.

1. Lower Continental Deposits. The lower continental deposits (gravel facies) are a basal gravel facies consisting of chert gravel in a matrix of poorly sorted sand and silt. The lower continental deposits have been found at three distinct horizons in the PGDP area.

   - The first horizon consists of the terrace gravels [consisting of a Pliocene (?) gravel ranging in thickness from 0 to 30 ft], occurring in the southern portion of PGDP area at elevations greater than 350 ft above mean sea level (amsl), and overlying the Eocene sands and Porters Creek Clay. The terrace gravels are a potential source of the sediments forming the RGA.

   - The second gravel horizon is terrace gravels located in the southeastern and eastern portions of the DOE boundary on an erosional surface at ~320 to 345 ft amsl. The thickness of this unit ranges from 15 to 20 ft.

   - The third and most prominent of the three horizons consists of a Pleistocene gravel deposit resting on an erosional surface at ~280 ft. This gravel is found throughout the plant area and to the north, but pinches out to the south along the slope of the Porters Creek terrace. The gravel deposit averages ~30 ft in thickness, but some thicker deposits (as much as 50 ft) exist in deeper scour channels that trend east-west across the site.

2. Upper Continental Deposits. The upper facies is composed of fine-grained clastics varying in thickness from 15 to 55 ft. These upper continental deposits have been differentiated into three general horizons: (1) an upper silt and clay interval, (2) an inner-bedded sand and gravel interval, and (3) a lower silt and clay interval. The sand and gravel interval appears relatively discontinuous in cross sections, and portions may be inner-connected.

4.5.7 Surficial Deposits/Soils

The surficial deposits found in the vicinity of PGDP are Pleistocene to Recent in age and consist of loess and alluvium. Both units are composed of clayey silt or silty clay and range in color from yellowish-brown to brownish-gray or tan, making field differentiation difficult.

The loess (wind-blown) deposits overlie the upper continental deposits over the entire PGDP area. Loess deposition probably occurred in upland areas during all stages of the glaciation that extended into the Ohio and Mississippi River Valleys.

4.6 HYDROGEOLOGY OF PGDP

Information presented herein regarding the groundwater setting was derived from the *Report of the Paducah Gaseous Diffusion Plant Groundwater Investigation Phase III* (Clausen et al. 1992). The discussion is intended to provide the reader with a general overview of the groundwater flow regime for PGDP. The local groundwater flow system at the PGDP site occurs within the sands of the Cretaceous McNairy Formation, Pliocene terrace gravels, Pleistocene lower continental gravel deposits and upper continental deposits, and Holocene alluvium. Four specific components have been identified for the groundwater flow system and are defined in the following paragraphs:

1. **McNairy Flow System.** Formerly called the deep groundwater system, this component consists of the interbedded and interlensing sand, silt, and clay of the Cretaceous McNairy Formation. Sand facies account for 40 to 50% of the total formation's thickness of ~225 ft. Groundwater flow is predominantly north.

2. **Terrace Gravels.** This component consists of Pliocene (?)-aged gravel deposits and later reworked sand and gravel deposits found at elevations higher than 320 ft amsl in the southern portion of the plant site; they overlie the Paleocene Porters Creek Clay and Eocene sands. These deposits usually lack sufficient thickness and saturation to constitute an aquifer.

3. **RGA.** This component consists of the Quaternary sand and gravel facies of the lower continental deposits and Holocene alluvium found adjacent to the Ohio River and is of sufficient thickness and saturation to constitute an aquifer. These deposits are commonly thicker than the Pliocene (?) gravel deposits, having an average thickness of 30 ft, and range up to 50 ft along an axis that trends east–west through the plant site. The RGA is the primary local aquifer. Groundwater flow is predominantly north toward the Ohio River.

4. **UCRS.** Formerly called the shallow groundwater system, this component consists of the surficial alluvium and upper continental deposits. Sand and gravel lithofacies appear relatively discontinuous in cross section, and portions may be inter-connected. The most prevalent sand and gravel deposits occur at an elevation of ~345 to 351 ft amsl; less prevalent deposits occur at elevations of 337 to 341 ft amsl. Groundwater flow is predominantly downward into the RGA from the UCRS, which has a limited horizontal component in the vicinity of PGDP.

Five hydrostratigraphic units (HUs) proposed by Douthitt and Phillips (1991) explain groundwater flow at the PGDP site. In descending order, the HUs are as described below.

- Upper Continental Deposits
  - HU 1 (UCRS): Loess that covers the entire site.
  - HU 2 (UCRS): Discontinuous, sand and gravel lenses in a clayey silt matrix.
  - HU 3 (UCRS): Relatively impermeable clay layer that acts as the upper semiconfining to confining layer for the RGA. The lithologic composition of this unit varies from clay to sand but is predominantly clay or silt.
  - HU 4 (RGA): Predominantly continuous sand unit with a clayey silt matrix that directly overlies the RGA. This unit is in hydraulic connection with HU 5 and is included as part of the RGA.
- Lower Continental Deposits
  - HU 5 (RGA): Gravel, sand, and silt

Transmissive zones of groundwater within the UCRS typically are restricted to relatively thin (generally less than 1 ft), discontinuous sand lenses within the tighter silty-clay matrix. These sand lenses do not have significant lateral extent. Monitoring wells (MWs) screened in the UCRS will not display consistent groundwater levels because of strong vertical gradients. Previous investigations have concluded that some of the buried waste is in contact with UCRS water at least during portions of the year (DOE 1997b; DOE 1998b).

Relatively few UCRS MWs are located near any of the burial cells described in this report. Table 4.1 details information regarding nearby UCRS MWs for each SWMU.

Table 4.1 UCRS MWs Near BGOU SWMUs

SWMU	MWs	Location/distance
SWMUs 2 and 3	MWs 82, 83, 85, 88, 91, 94, 154	~50 ft north, east, south
SWMU 4	MW 94	~200 ft north
SWMU 5	MW 190	~50 ft north
SWMU 6	MW 172	~360 ft southeast
SWMU 7	MW186	~ 5 ft north
SWMU 30	MWs 64 and 187	up to ~ 30 ft west
SWMU 145	MWs 371, 374, 377, 386, 390, 393	Distance varies from within the SWMU to ~700 west, northwest, and north

SWMUs 2 and 3. Seven UCRS MWs are in the immediate vicinity of SWMUs 2 and 3. Four wells are arrayed along the northern boundary of the SWMU (MWs 154, 85, 91, and 82). One well (MW 88) is east of SWMU 3, and one well (MW94) is on the sourthern boundary of the SWMU. Very little groundwater data has been collected from these wells over the previous two years (e.g., MWs 82, 83, and 154 have only been monitored once). The remaining four wells have been monitored four times (January and July of 2004 and 2005), with the exception of MW294, which was not monitored in July 2004. For each of the four wells, groundwater levels have remained consistent, with variations typically less than 10% between highest and lowest reading. [e.g., MW91 depth to water (dtw) was measured at 9.38 ft below ground surface (bgs) in January 2005 and 8.73 ft bgs in July 2005.] Each of the other three wells displayed groundwater levels at similar depths and with similar fluctuations.

SWMU 4. One UCRS MW is approximately 200 ft to the north of SWMU 4 – MW94. This well has been monitored only three times in the previous two years, January 2004 and January and July 2005. Seasonal fluctuations were minimal between these readings, approximately 5% between the highest elevation reading (July 2005) and the lowest reading (January 2004).

SWMU 5. One UCRS MW is approximately 50 ft to the north of SWMU 5 – MW190. This well has been monitored only once in the previous two years, September 2005, and the recorded dtw was 3.6 ft bgs.

SWMU 6. One UCRS MW is approximately 360 ft to the southwest of SWMU 6 – MW172. This well has been monitored only once in the previous two years, September 2005, and the recorded dtw was 6.27 ft bgs. [Note the elevation difference between MW172 (elevation 374.1) and MW190 (elevation 373.6), north of SWMU 5, is significantly less than the groundwater levels, recorded on the same day. These wells were screened at different intervals, suggesting that the groundwater encountered in each of these wells is from discontinuous zones.]

SWMUs 7 and 30. Three UCRS MWs are within approximately 30 ft of SWMUs 7 and 30 – MW64, MW186, and MW187. MW64 has been monitored only once in the previous two years, September 2005, and the recorded dtw was 4.71 ft bgs. MW186 and MW187 have been monitored semi-annually. In June 2005, the recorded dtw entries were 5.39 ft bgs and 3.89 ft bgs, respectively.

SWMU 145. Seven UCRS MWs have been installed west, northwest, and north of SWMU 145. These wells have been monitored at various intervals during the previous two years – in January, April, July, August, and October of both years. Seasonal fluctuations vary significantly from one well to the other. For instance, MW 374 shows groundwater level variation of ~12 ft, with the lowest reading of

35.71 ft bgs in January 2005 and the highest reading of 23.33 ft bgs in April 2004. Other MWs displayed significantly less variation in high and low readings, with most wells showing a range of variation less than 2 ft. Also, within the data set there seems to be no consistent variation attributable to seasonal variation. For instance, the highest reading in MW377 was in July 2005, and the lowest reading was in January 2005.

4.7 SURFACE WATER HYDROLOGY

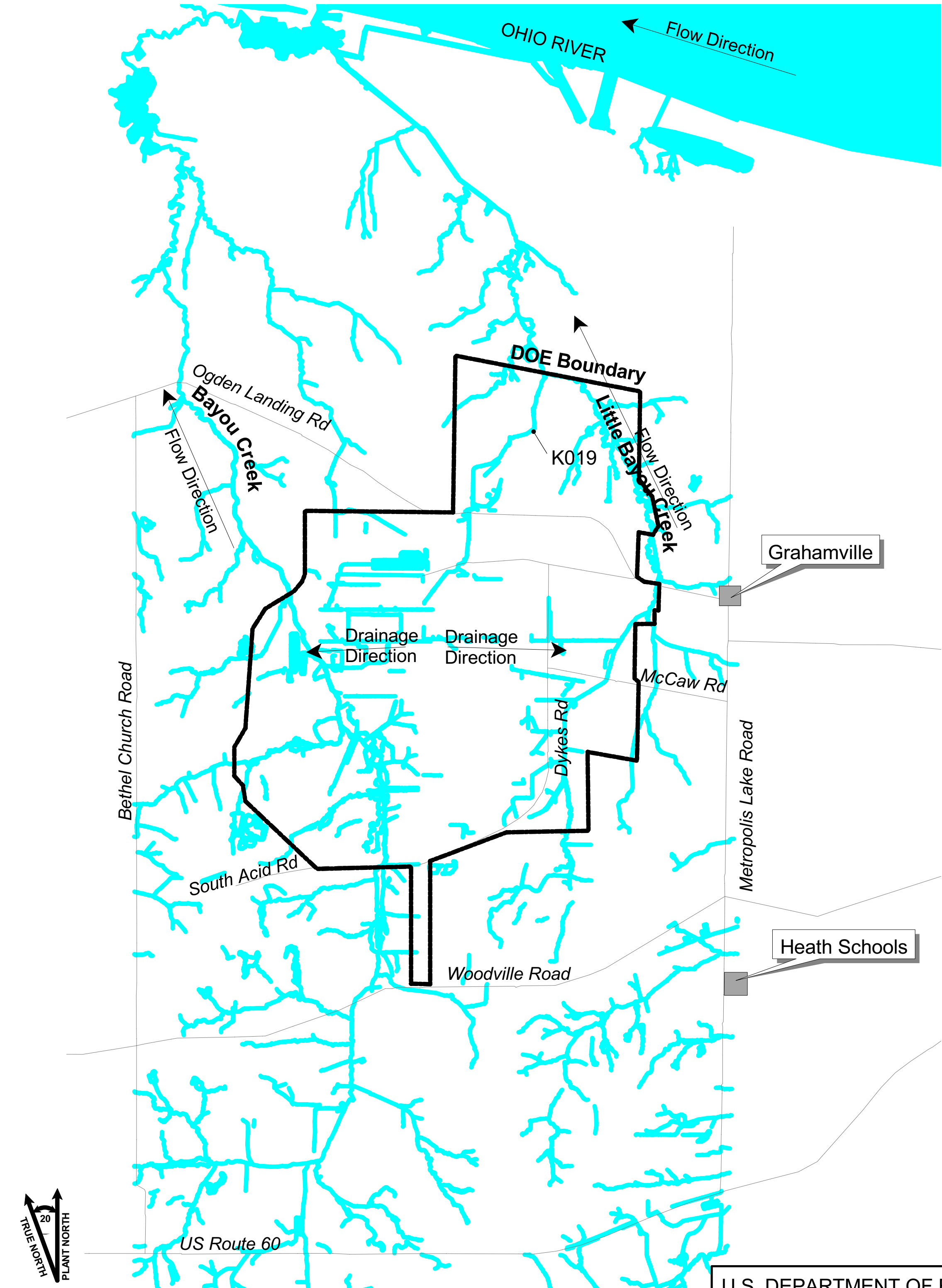
Information presented herein regarding the surface water setting at PGDP was derived from Results of the Site Investigation, Phase II (CH2M HILL 1992). PGDP is located in the western portion of the Ohio River basin. Locally it is within the drainage areas of Bayou Creek (also known as Big Bayou Creek) and Little Bayou Creek; the plant is situated on the divide between the two creeks (Figure 4.3). Bayou Creek is a perennial stream that flows generally northward from ~2.5 miles south of the plant site to the Ohio River and extends along the western boundary of the plant. Little Bayou Creek, also a perennial stream, originates within WKWMA, flows northward to the Ohio River, and extends along the eastern boundary of the plant. The confluence of the two creeks is ~3 miles north of the plant site, just upstream of the location at which the creeks discharge into the Ohio River. The drainage areas for both creeks are generally rural; however, they receive surface drainage from numerous swales that drain residential and commercial properties, including WKWMA, PGDP, and the TVA Shawnee Steam Plant. A major portion of the flow in both creeks north of PGDP is effluent water from the plant discharged through Kentucky Pollutant Discharge Elimination System (KPDES) outfalls.

Surface water bodies in the vicinity of PGDP include the Ohio River; Metropolis Lake, located east of the Shawnee Steam Plant; several small ponds, clay and gravel pits, and settling basins scattered throughout the area; drainage ditches located within PGDP; and a marshy area just south of the confluence of Bayou Creek and Little Bayou Creek. The smaller surface water bodies are expected to have only localized effects on the regional groundwater flow pattern.

Man-made or altered drainageways within and surrounding PGDP also receive and transmit surface waters. The on-site ditches direct surface water runoff and plant discharges to off-site receiving streams. The plant ditches generally are considered to be located in areas in which the local groundwater table is controlled by the bottom of the primary ditch channels.

4.8 ECOLOGICAL SETTING OF PGDP

The following sections give a brief overview of the terrestrial and aquatic systems at PGDP. A more detailed description, including identification and discussion of sensitive habitats and threatened/endangered species, is contained in the Investigation of Sensitive Ecological Resources Inside the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (CDM Federal 1994) and Environmental Investigations at the Paducah Gaseous Diffusion Plant and Surrounding Area, McCracken County, Kentucky [U.S. Army Corps of Engineers (COE) 1994].



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PADUCAH GASEOUS DIFFUSION PLANT

Figure 4.3. Surface Water Features in the Vicinity of the DOE Site

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4.8.1 Terrestrial Systems

The terrestrial component of the PGDP ecosystem includes the plants and animals that use the upland habitats for food, reproduction, and protection. The upland vegetative communities consist primarily of grassland, forest, and thicket habitats with agricultural areas. The main crops grown in the PGDP area include soybeans, corn, tobacco, and sorghum.

Most of the area in the vicinity of PGDP has been cleared of vegetation at some time, and much of the grassland habitat is currently mowed by PGDP personnel. A large percentage of the adjacent WKWMA is managed to promote native prairie vegetation by burning, mowing, and various other techniques. These areas have the greatest potential for restoration and for establishment of a sizeable prairie preserve in the Jackson Purchase area [Kentucky State Nature Preserves Commission (KSNPC) 1991].

Dominant overstory species of the forested areas include oaks, hickories, maples, elms, and sweetgum. Understory species include snowberry, poison ivy, trumpet creeper, Virginia creeper, and Solomon's seal.

Thicket areas consist predominantly of maples, black locust, sumac, persimmon, and forest species in the sapling stage with herbaceous ground cover similar to that of the forest understory.

Wildlife commonly found in the PGDP area consists of species indigenous to open grassland, thicket, and forest habitats. The species documented to occur in the area are discussed in the following paragraphs.

Small mammal surveys conducted on WKWMA documented the presence of southern short-tailed shrew, prairie vole, house mouse, rice rat, and deer mouse (KSNPC 1991). Large mammals commonly present in the area include coyote, eastern cottontail, opossum, groundhog, whitetail deer, raccoon, and gray squirrel.

Typical birds of the area include European starling, cardinal, red-winged blackbird, mourning dove, bobwhite quail, turkey, killdeer, American robin, eastern meadowlark, eastern bluebird, bluejay, red-tail hawk, and great horned owl.

Amphibians and reptiles present include cricket frog, Fowler's toad, common snapping turtle, green tree frog, chorus frog, southern leopard frog, eastern fence lizard, and red-eared slider (KSNPC 1991).

Mist netting activities in the area have captured red bat, little brown bat, Indiana bat, northern long-eared bat, evening bat, and eastern pipistrelle (KSNPC 1991).

4.8.2 Aquatic Systems

The aquatic communities in and around the PGDP area that could be impacted by plant discharges include two perennial streams [Bayou Creek (named in other documents as Big Bayou Creek) and Little Bayou Creek], the NSDD, a marsh located at the confluence of Bayou Creek and Little Bayou Creek, and other smaller drainage areas. The dominant taxa in all surface waters include several species of sunfish, especially bluegill and green sunfish, as well as, bass and catfish. Shallow streams, characteristic of the two main area creeks, are dominated by bluegill, green and longear sunfish, and stonerollers.

4.8.3 Wetlands and Floodplains

Wetlands were identified during the 1994 COE's environmental investigations of 11,719 acres surrounding PGDP. These investigations identified 1083 separate wetland areas and grouped them into 16 vegetative cover types encompassing forested, scrub/shrub, and emergent wetlands (COE 1994). Wetland vegetation consists of species, such as sedges, rushes, spikerushes, and various other grasses and forbs in the emergent portions; red maple, sweet gum, oaks, and hickories in the forested portions; and black willow and various other saplings of forested species in the thicket portions.

Before field mobilization for the RI field activities, the wetlands, previously identified during a delineation conducted in 1994, will be flagged in the field at each of the three SWMU areas. The RI field team will take necessary measures to ensure that the wetlands are avoided to the extent practicable. Best Management Practices will be employed during field activities to keep sediments out of the wetland areas and to minimize other impacts. A list of Best Management Practices to be employed can be found in the substantive requirements outlined in Nationwide Permit 38.

At the PGDP, three bodies of water cause most area flooding: the Ohio River, Bayou Creek, and Little Bayou Creek. A floodplain analysis performed by COE (1994) found that much of the built-up portions of the plant lie outside the 100- and 500-year floodplains of these streams. In addition, this analysis reports that ditches within the plant area can contain the expected 100- and 500-year discharges.

4.9 CLIMATOLOGY OF PGDP

Information presented herein regarding the climatology at PGDP was derived from the Results of the Site Investigation, Phase II (CH2M HILL 1992). The region in which the plant is located has a humid-continental climate characterized by extremes of both temperature and precipitation. The 20-year average monthly precipitation is 4.19 in., varying from an average of 2.99 in. in January to an average of 5.16 in. in April. From March through July and during November and December, the weather is generally wetter than average, while from August through October and during January and February, the weather is generally drier than average. The 20-year average monthly temperature is 57.1ºF, varying from 29.9ºF in January to 79.0°F in July.

5. CHARACTERIZATION OF SITE/PREVIOUS ANALYTICAL DATA

Several documents have been produced containing data pertinent to the various SWMUs within the BGOU. In most cases, the previously prepared documents grouped several SWMUs together and did not study one particular SWMU. These documents and the various MWs installed throughout PGDP provide considerable usable data for this RI/FS Work Plan. Data, limited to the past ten years for screening purposes, were downloaded from the Paducah Oak Ridge Environmental Information System (OREIS) database in July 2004 (BJC 2004b). In addition, any previously rejected data were eliminated from the data set. The historical data set was used to compile various risk-screening tables required by the methods document for scoping activities. This information is provided in Appendix E of this document. In addition, a compact disk provided in Appendix G contains the three-dimensional figures that appear later in this chapter. Each figure provides a scale bar representing the contaminant levels for the analyte found within the SWMU. The discrete dots represent a sample result. Lines are drawn between the dots to represent samples within a continuous boring. The uppermost back side of the three-dimensional figure typically represents plant north. The contaminants chosen for modeling were based on contaminants detected above action levels from the risk screening process and showing a sufficient number of detections for valuable presentation. For some SWMUs, such as SWMUs 7 and 30, TCE is modeled, even though it did not meet this criteria in order to show that it was evaluated in the historical data set.

Since the completion of the scoping document, additional groundwater data have been generated from routine MWs, as well as specific SIs for the C-746-S&T Landfills area and the Southwest Groundwater Plume areas. A supplemental groundwater data set from OREIS, for the period June through July 2004, also was added to the historical data set for the activities listed in this paragraph.

5.1 SITE DESCRIPTION

5.1.1 C-749 Uranium Burial Ground (SWMU 2)

5.1.1.1 Area description

The C-749 Uranium Burial Ground (SWMU 2 – Figure 5.1) is located within the west-central portion of the plant north of Virginia Avenue inside the security-fenced area at PGDP. SWMU 2 encompasses an area of approximately 32,000 ft^2, with approximate dimensions of 160 by 200 ft. Records indicate that when the burial ground was in use, pits were excavated to an estimated depth of 7 to 17 ft. After the burial ground no longer was in use, the area was covered with a 6-in.- thick clay cap and a 18-in.- thick soil layer covered with vegetation (DOE 1995).

5.1.1.2 Process history

SWMU 2 was used from 1951 to 1977 for the disposal of uranium and uranium-contaminated wastes. Disposal records for SWMU 2 indicate that 270 tons of uranium, 59,000 gal of oils, and 450 gal of TCE were disposed of in the unit (DOE 1999a). Disposal records also indicate that drummed wastes buried in the unit consist primarily of uranium metal from machine shop turnings, shavings, and sawdust. Other wastes at the unit consist of drummed uranyl fluoride and TCE. Because small pieces of uranium metal may be pyrophoric (spontaneously burn in air), operating practices of that time required placing the material in drums and submerging the material in petroleum-based oil and synthetic oil to avoid contact with air.

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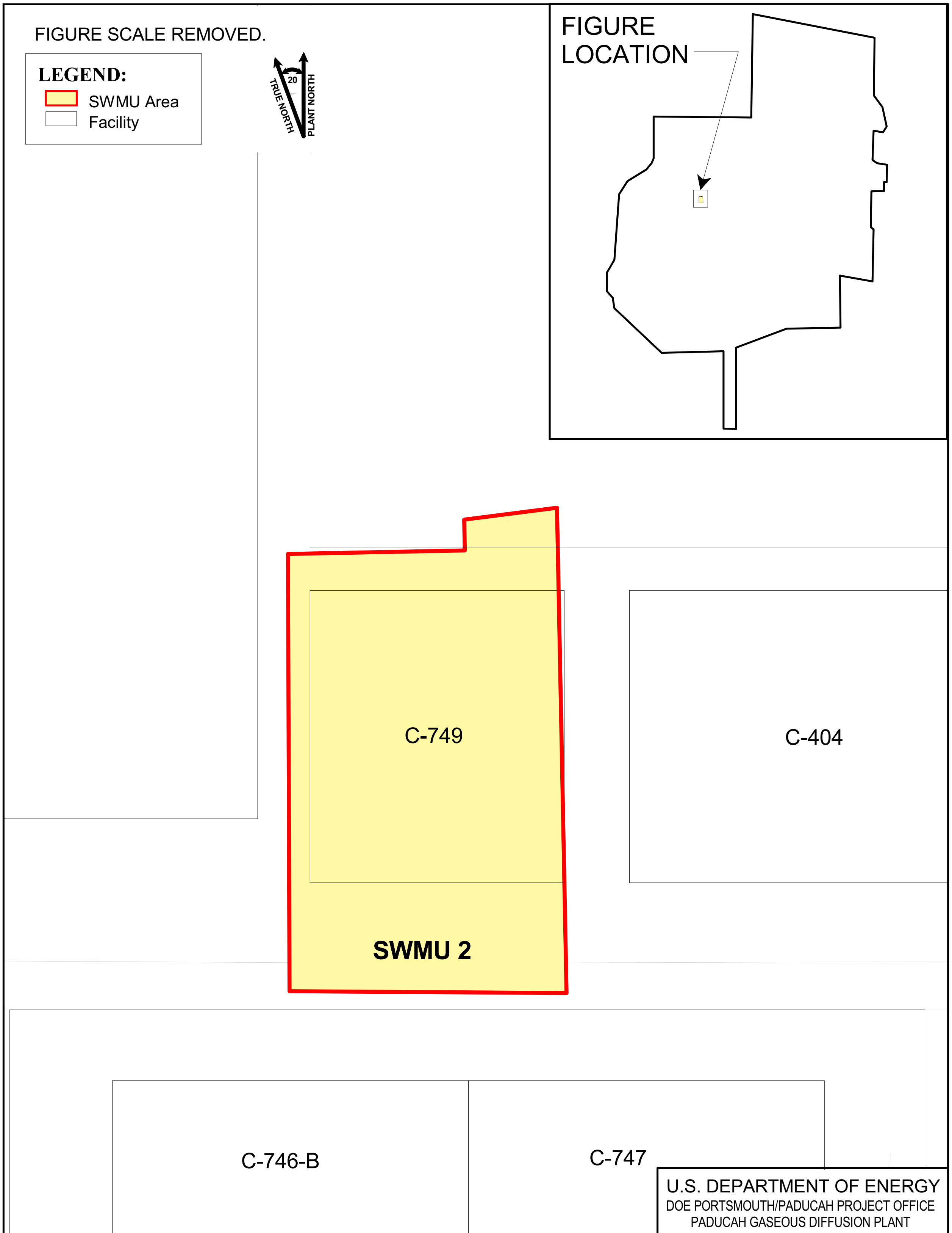

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Figure 5.1. SWMU 2

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Most of the waste in the unit is believed to consist of pyrophoric uranium metal in the form of machine shop turnings, shavings, and sawdust. Pyrophoric uranium metal usually was placed in 20-, 30-, or 55-gal drums. Occasionally, underground fires were reported as a result of oxidation of pyrophoric uranium metal, but no subsidence has been observed as a result of volume reductions due to the fires. It is possible that the oils used may have included some PCB-contaminated oils. Other forms of uranium, including oxides of uranium (solid and dissolved in aqueous solutions), uranyl-fluoride solutions, uranium-zirconium alloy, slag, and uranium tetrafluoride, were buried in small quantities (DOE 1996).

The most likely scenario is that the uranium buried at PGDP is in the metallic state or is coated with uranium (IV) oxide. Neither of these forms of uranium is very susceptible to leaching. The kinetics of dissolution of the buried metal and uranium (IV) oxide is controlled by the amount of oxygen and carbon dioxide that leaches through the waste. Site records show that much of the metal was coated with oil, in many cases, PCB-oil. Such oils are resistant to chemical and biological degradation and from leaching by percolating waters. In addition, oils, as they slowly degrade, consume oxygen, which lowers the oxidation-reduction potential. Under such conditions, uranium dissolution is negligible (ORNL 1998).

No documentation of ^{99}Tc disposal at SWMU 2 exists. However, during the years of feed plant operation from 1953 to 1964 and from 1968, intermittently through 1977, recycled uranium feed material from nuclear reactors were reprocessed through the feed plant, resulting in the introduction of reactor-produced radioactive impurities, such as ^{99}Tc, into the enrichment process. It is possible that a portion of the uranium-contaminated wastes disposed of in burial grounds at PGDP contains ^{99}Tc from reprocessing activities. This assumption is supported by the detection of ^{99}Tc in groundwater samples taken from MWs near SWMU 2 (DOE 1994).

Materials contaminated with TCE also are known to have been disposed of at SWMU 2. In August 1984, Area 9 of SWMU 2 was excavated due to concern about the integrity of TCE-containing drums (15 30-gal drums) reportedly disposed of in this area. Little documentation is available concerning this excavation. However, it is reported that during excavation, four 30-gal drums and 35 55-gal drums (30 of these drums contained uranium sludges, not TCE) were recovered; some of these drums were in poor condition. Some drums found were not on the original listing, as buried in that area (DOE 1995). The material was left within the SWMU and re-covered.

Previous documents that included information from investigations in the area surrounding SWMU 2 were completed in 1995, 1996, 1997, 1998, and 2003. In addition, data are collected continually from MWs positioned throughout PGDP to track plume movement.

5.1.1.3 Surface water hydrology

The SWMU 2 and SWMU 3 sites, combined, are approximately 5 acres in size. SWMU 2 is slightly mounded, with surface elevations ranging between 370 and 377 ft amsl. Ditches to the north and south of SWMUs 2 and 3, and to the east of SWMU 3, are approximately 2 to 6 ft deep. These ditches discharge through KPDES Outfall 015 to Bayou Creek.

The surface of the SWMU and the surrounding ditches are grass-covered, except for areas of gravel pads placed during previous investigations for drill rig access. Discharge through Outfall 015 includes surface runoff from the west central plant area. Flow through the outfall is erratic in response to rainfall events (DOE 1994).

5.1.1.4 Stratigraphy

Surficial deposits within the area surrounding SWMUs 2 and 3 consist of 16 to 20 ft of lean clay. The surficial deposits are included in the Henry Silt Loam soil series and consist of silt loam and silty clay loam. These soils are poorly drained, with water standing at the surface during wet periods. A low-permeability layer (fragipan) typically is present at depths ranging from 1 to 4 ft bgs and is 1 to 2 ft thick. Because the fragipan restricts vertical drainage, water typically perches on this layer during the winter and spring, causing a seasonally high zone of saturation near the surface. Excavation beneath the burial mounds probably has disturbed the fragipan layer, resulting in higher vertical-flow potential of water and leachate (DOE 1994).

Results from the double-ring infiltrometer tests conducted on surface soils at SWMU 2 confirm that a 12.7-cm (6-in.) clay cap exists at this SWMU. The unit was capped in 1982 with a 6-in. clay cap, with a permeability of 2.8×10^{-4} ft/day and an 18 in. thick topsoil to promote vegetative cover.

The Upper Continental Deposits underlying these surface soils are encountered at an elevation of 351 to 358 ft amsl, at a depth of approximately 13 to 20 ft bgs. The unit ranges in thickness from 42 to 62 ft near SWMU 2. The typical soil type is sandy clay with interlayers of sand at various depths.

The Lower Continental Deposits are approximately 20 to 30 ft thick, with the top elevation at 310 to 315 ft amsl near SWMU 2. The lithology is predominantly well-rounded chert gravel with sand. Based on previous PGDP subsurface investigations, the gravel is underlain by the McNairy Formation at elevations of 270 to 280 ft amsl.

The stratigraphy is summarized in the Lithologic Database presented in Appendix 3B of the Phase II Report (CH2M HILL 1992).

5.1.1.5 Hydrology

The current conceptual model of the groundwater hydraulics within the UCRS shows groundwater flows primarily downward. This downward migration flows through interconnected sand lenses within the UCRS and is driven by the vertical gradients, which are much greater than the horizontal gradients. The effective lateral extent of horizontal gradients is difficult to define due to the lenticular nature of these sand deposits.

The horizontal gradient in the RGA is approximately 0.00027 ft/ft toward the northwest. Assuming an effective porosity of 0.2, the calculated flow velocity within the RGA at SWMU 2 was estimated to be approximately 0.1 ft/day. Due to the low hydraulic gradient, actual flow directions may be governed by other factors, such as localized changes in material types and anisotropy (CH2M HILL 1992). Because SWMU 2 is located over ancestral river channel deposits that underlie the PGDP, flow may follow a preferred east–west orientation.

5.1.2 C-404 Low-Level Radioactive Waste Burial Ground (SWMU 3)

5.1.2.1 Area description

The C-404 Low-Level Radioactive Waste Burial Ground (SWMU 3 – Figure 5.2) is 1.2 acres located in the west-central portion of the secured area. The unit originally was constructed as a rectanglar

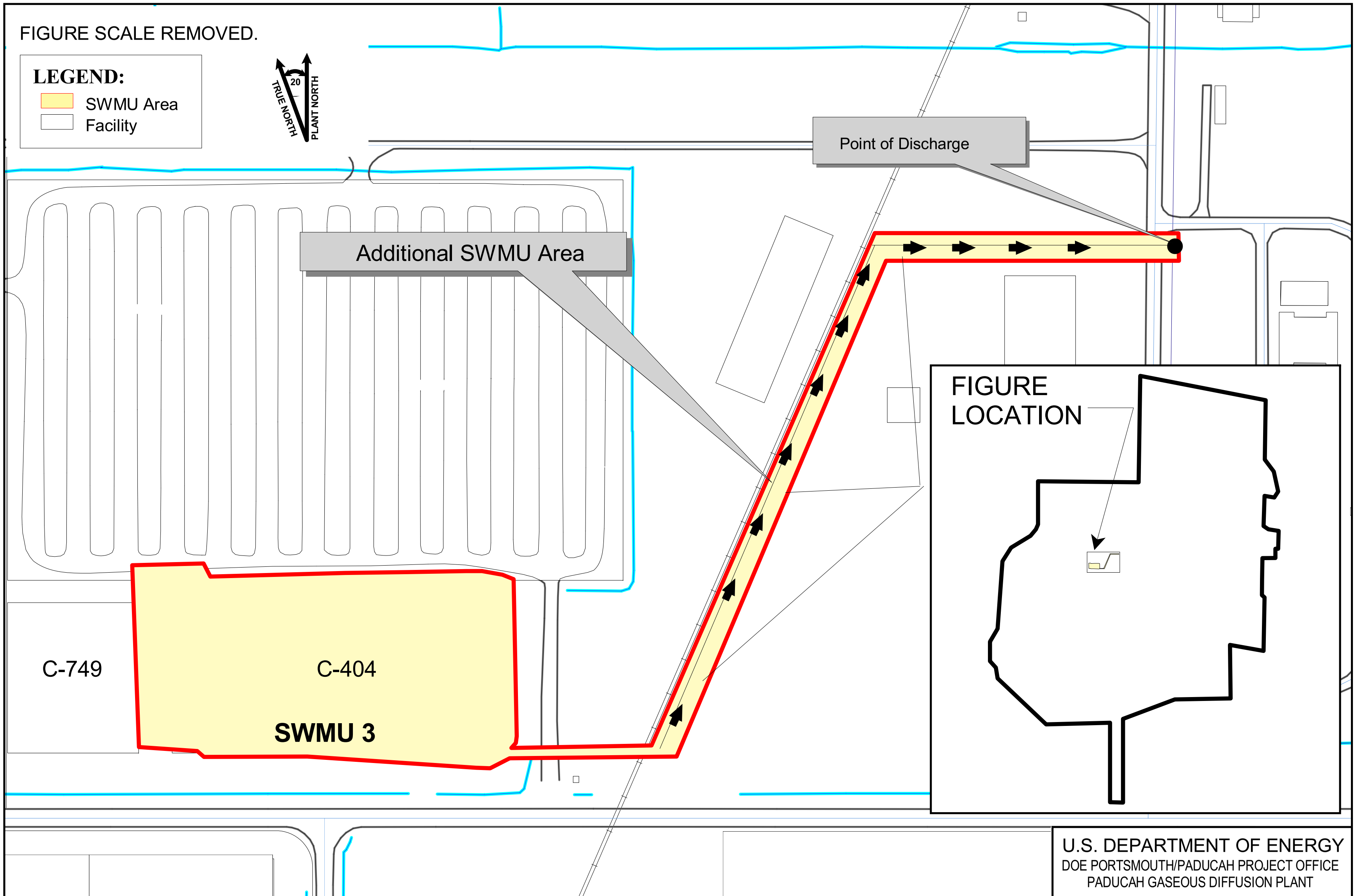

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Figure 5.2. SWMU 3

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aboveground, surface impoundment measuring 387 by 137 ft with a floor area of approximately 53,000 ft^2. The floor of the surface impoundment was constructed of well-tamped earth and clay dikes to a depth of 6 ft. The C-404 impoundment was designed with an overflow weir at its southwest corner. From the weir, the surface impoundment effluent flowed west in a ditch (not the NSDD) and eventually discharged into KPDES Outfall 015. The same cross section is used for SWMUs 2 and 3 due to similar hydrology and stratigraphy.

In March 2003, an additional 37,000 ft^2 of area were added to the SWMU when a northeast-southwest ditch just east of SWMU 3 was included as part of the SWMU. This ditch was impacted by the discharge of a now-abandoned pipeline with historic leachate flow into the NSDD (DOE 2003a). When the C-404 impoundment was converted into a disposal facility, a sump was installed at the weir. The sump was used to pump leachate into an underground transfer line. The transfer line discharged into a northeast-southwest ditch just east of C-404. From this ditch, the leachate flowed into the NSDD. A partial clay cap was installed on the eastern end of the landfill in 1982. The date of termination of the leachate discharge from the underground transfer line to the NSDD has not been determined. However, it is known that, prior to landfill closure in 1986, this underground transfer line into the NSDD was not in operation, and leachate from the C-404 Landfill was being collected in the sump for treatment at C-400. The wastewater from the treatment of the leachate was discharged to C-403 and, ultimately, to the NSDD. At some time following closure of C-404 Landfill, treatment of leachate from C-404 at C-400 was discontinued and treatment of the leachate was transferred to C-752.

5.1.2.2 Process history

SWMU 3 operated as a surface impoundment from approximately 1952 until early 1957. During this time, all influents to the impoundment originated from C-400. In 1957, the C-404 surface impoundment was converted to a solid waste disposal facility for solid uranium-contaminated wastes. The waste consists of uranium precipitated from aqueous solutions, uranium tetrafluoride, uranium metal, uranium oxides, and radioactively contaminated trash. There are no records documenting the cleanout of sludges and sediments from the pond when it was converted to a landfill. When the C-404 impoundment was converted into a disposal facility, a sump was installed at the weir. Leachate was pumped from the sump through an underground transfer line. The transfer line discharged into a northeast-southwest ditch just east of C-404. From this ditch, the leachate flowed into the NSDD. The upper tier of wastes contains the same types of wastes that were collected in the impoundment plus smelter furnace liners and drums of extraction-procedure, characteristically hazardous, waste (RCRA waste codes D006, D008, and D010). A partial clay cap was installed on the eastern end of the landfill in 1982 (DOE 1987).

Approximately 6,615,000 lb of uranium-contaminated wastes were disposed of at SWMU 3. The total volume is approximately 260,000 ft^3. Some uranium-contaminated waste also is contaminated with TCE, radionuclides, and metals. In 1986, the disposal of any waste at C-404 Landfill was halted, and a portion of the disposed waste was found to be RCRA-hazardous. The landfill was covered with a RCRA multilayered cap and certified closed in 1987. It currently is regulated under RCRA as a land disposal unit and compliance is required by a RCRA postclosure permit issued in 1992. This closure plan requires continued groundwater monitoring (DOE 1989).

The date of termination of the leachate discharge through the underground transfer line into the NSDD has not been determined. It is known that, prior to landfill closure in 1986, this underground transfer line to the NSDD was not in operation, and leachate from the C-404 Landfill was being collected in the sump for treatment at C-400. The wastewater from the treatment of the leachate was discharged to C-403 and, ultimately, to the NSDD. At some time following closure of the C-404 Landfill, treatment of leachate from C-404 at C-400 was discontinued, and treatment of the leachate was transferred to C-752.

Previous documents that included information from investigations in the area surrounding SWMU 3 were completed in 1995, 1996, 1997, 1998, and 2003. In addition, data are continually collected from MWs positioned throughout the PGDP. Because SWMU 3 is closed with a RCRA cap and is being addressed by RCRA postclosure permit requirements, SWMU 3 was not addressed in the *Record of Decision for Interim Remedial Action at Solid Waste Management Units 2 and 3 of Waste Area Group 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1995).

5.1.3 C-747 Contaminated Burial Yard and C-748-B Burial Area (SWMU 4)

5.1.3.1 Area description

The C-747 Contaminated Burial Yard and the C-748-B Burial Area (SWMU 4 – Figure 5.3) is located in the western section of the plant area. SWMU 4 (which covers an area of approximately 286,700 ft^2) is bounded on the north by Virginia Avenue, on the east by 6th Street, on the west by 4th Street, and on the south by an active railroad spur. This SWMU is an open grass field that, at one time, was used for the burial and disposal of various waste materials in designated burial cells. There have been no permanent structures built on the site. A short, narrow, gravel road that enters from 4th Street is nearly completely grass-covered. Except for this rarely used road, the entire site is covered with a variety of field grasses and clovers. The site typically is mowed once a month from April through September. SWMU 4 is bounded on three sides (north, east, and west) by shallow drainage swales that direct surface runoff to the northwest corner of the site. There is an elevation difference of approximately 10 ft between the highest point in the SWMU to the adjacent drainage swales. The entire burial yard was covered with 2 to 3 ft of soil material and a 6-in. clay cap was placed over the area in 1982 (DOE 1998c).

5.1.3.2 Process history

The C-747 Burial Yard was in operation from 1951 to 1958 for the disposal of radiologically contaminated and uncontaminated debris originating from the C-410 UF_6 feed plant. The area consists of two pits covering an area of approximately 8,300 ft^2 (50 ft. by 15 ft. and 50 ft. by 150 ft.) (Union Carbide 1978).

The C-748-B Burial Area is listed in the 1973 Union Carbide document on waste disposal as a Proposed Chemical Landfill Site and is located on the west side of C-747 and bounded by 4th Street and Virginia Avenue. The SWMU 4 boundary was revised at some time since the original SWMU Assessment Report and the dimensions of SWMU 4 were increased to include both the C-747 and the C-748-B units.

SWMU 4 also may have received sludges designated for disposal at the C-404 burial grounds. The source of these sludges is unknown, but the Waste Area Grouping (WAG) 3 RI Work Plan (DOE 1998c) indicated that the sludges potentially included uranium-contaminated solid waste and ^{99}Tc-contaminated magnesium fluoride. The total volume of material disposed at this site is unknown. Potential contaminants associated with this SWMU include uranium, ^{99}Tc, metals, and TCE (DOE 1998c).

In the fall of 1999, employee interviews led to designating the C-747 Burial Yard as a classified area. Access, subsequently was restricted based on security considerations. Also during the fall of 1999, a small (3 ft across and 3 ft deep) sinkhole developed in the southern burial cell. The sinkhole was backfilled with soil.

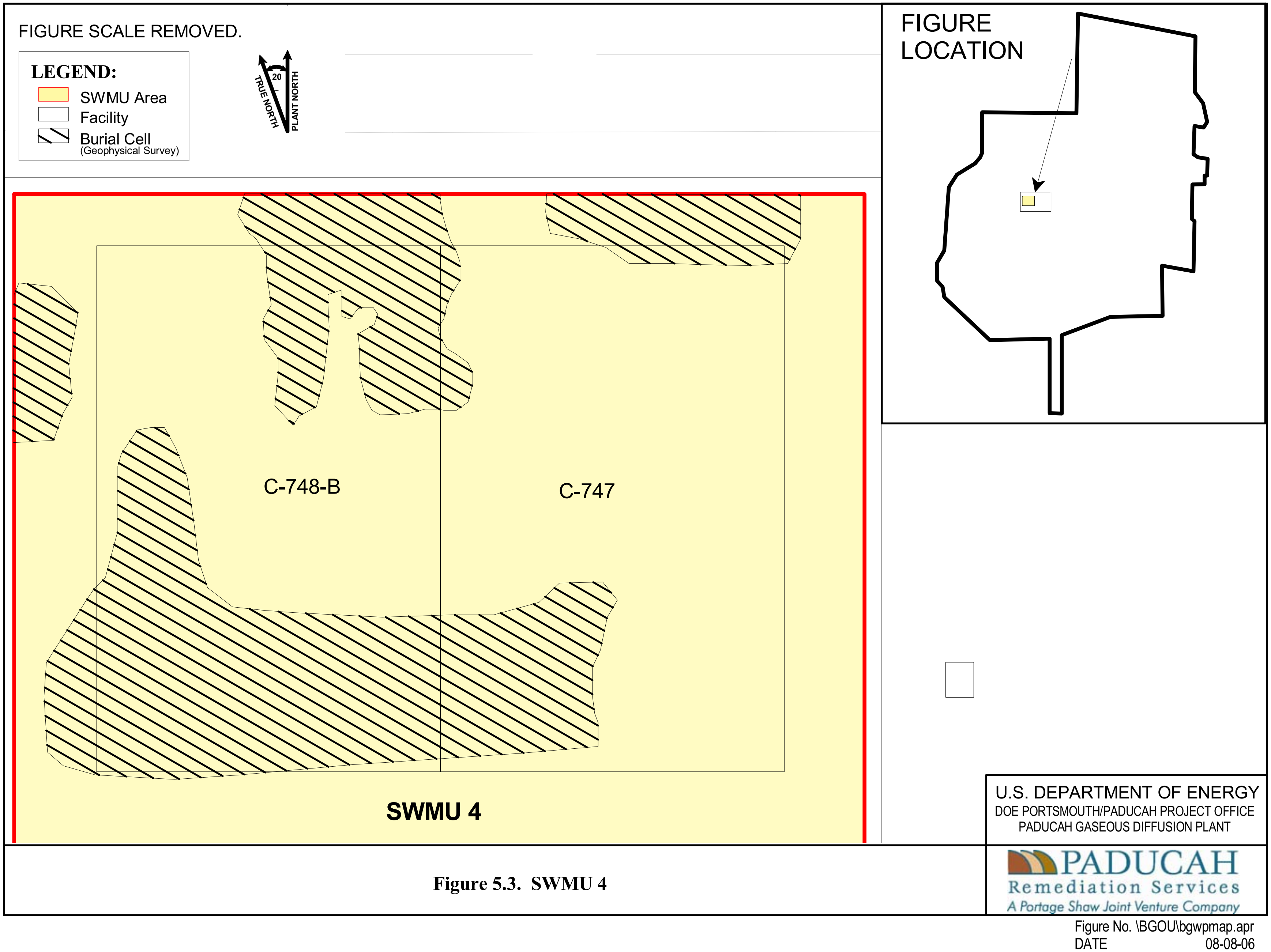

Figure 5.3. SWMU 4

5.1.3.3 Stratigraphy

The three primary units in the subsurface at SWMU 4, in ascending order, are as follows: the McNairy Formation, the RGA, and the UCRS. The McNairy Formation is predominantly gray lignitic clays and silts that subcrop at approximately 100 to 120 ft bgs. The McNairy sediments are overlaid by 40 to 60 ft of porous and permeable, coarse-grained sands and chert gravels of the RGA. The RGA is, in turn, overlaid by a fining-upward sequence of gravels, sands, silts, and clays that comprise the UCRS. Sands and gravels within the UCRS typically are fine-grained, poorly sorted, and occur as laterally discontinuous lenses within a matrix of finer-grained material (DOE 2000c).

The stratigraphy generally follows the conceptual model presented, with the notable exception that the base of the RGA dips down on the western edge of SWMU 4. This results in a thickening of the RGA in this area.

The physical and chemical properties of the subsurface soil and the depth to the water table at SWMU 4 play an important role in the migration and distribution of contaminants in the subsurface. The most common contaminants identified at the SWMU are volatile organic compounds (VOCs), radiological contaminants, PCBs, and metals. The downward mobility of metal ions would be expected to be inhibited by the low permeability of the clay-rich UCRS soil and by adsorption processes. However, the UCRS sediments are not an aquiclude, and leaching of contaminants and downward migration of precipitation toward the RGA would be expected to be a contaminant dispersion pathway at each of the sites investigated. Because most of the UCRS sediments are within the vadose zone and because of the lack of laterally continuous sands within the UCRS, conduits for long-distance lateral migration of contaminants in the shallow subsurface would not be expected to be a significant contaminant distribution process.

Downward-migrating contaminated fluids that reached the RGA then would be incorporated into the RGA groundwater and transported laterally to the west-northwest as part of the Southwest and/or Northwest Plumes. Because the McNairy Formation has a lower permeability than the overlying RGA sediments, and because groundwater flow typically will follow the path of least resistance, mixing of the contaminated RGA groundwater in the off-site plumes with the deeper McNairy flow system has not been extensive. As a result, McNairy groundwater samples collected during the WAG 3 RI were found to be relatively uncontaminated (and the limited contamination that was found does not appear to be attributable to the WAG 3 SWMUs).

5.1.4 C-746-F Burial Yard (SWMU 5)

5.1.4.1 Area description

The C-746-F Burial Yard is located in the northwestern section of the PGDP secured area. SWMU 5 (which covers an area of approximately 197,400 ft^2) is located adjacent to the C-746-P Scrap Yard to the north and SWMU 6 to the east (see Figure 5.4). Disposal pits were located on a grid system. Documentation of the size of these grids ranges from 10 by 10 ft cells to 20 by 20 ft cells excavated to a depth of 6 to 15 ft bgs. Figure 5.4 shows these cells as 20 by 20 ft; however, historical aerial photographs indicate earlier grid size may have been smaller. Waste placed in the yard disposal pits was covered with 2 to 3 ft of soil. SWMU 5 is fenced to limit access to authorized personnel only. The ground surface is covered with short grasses and various flowering herbaceous plants (DOE 1998c).

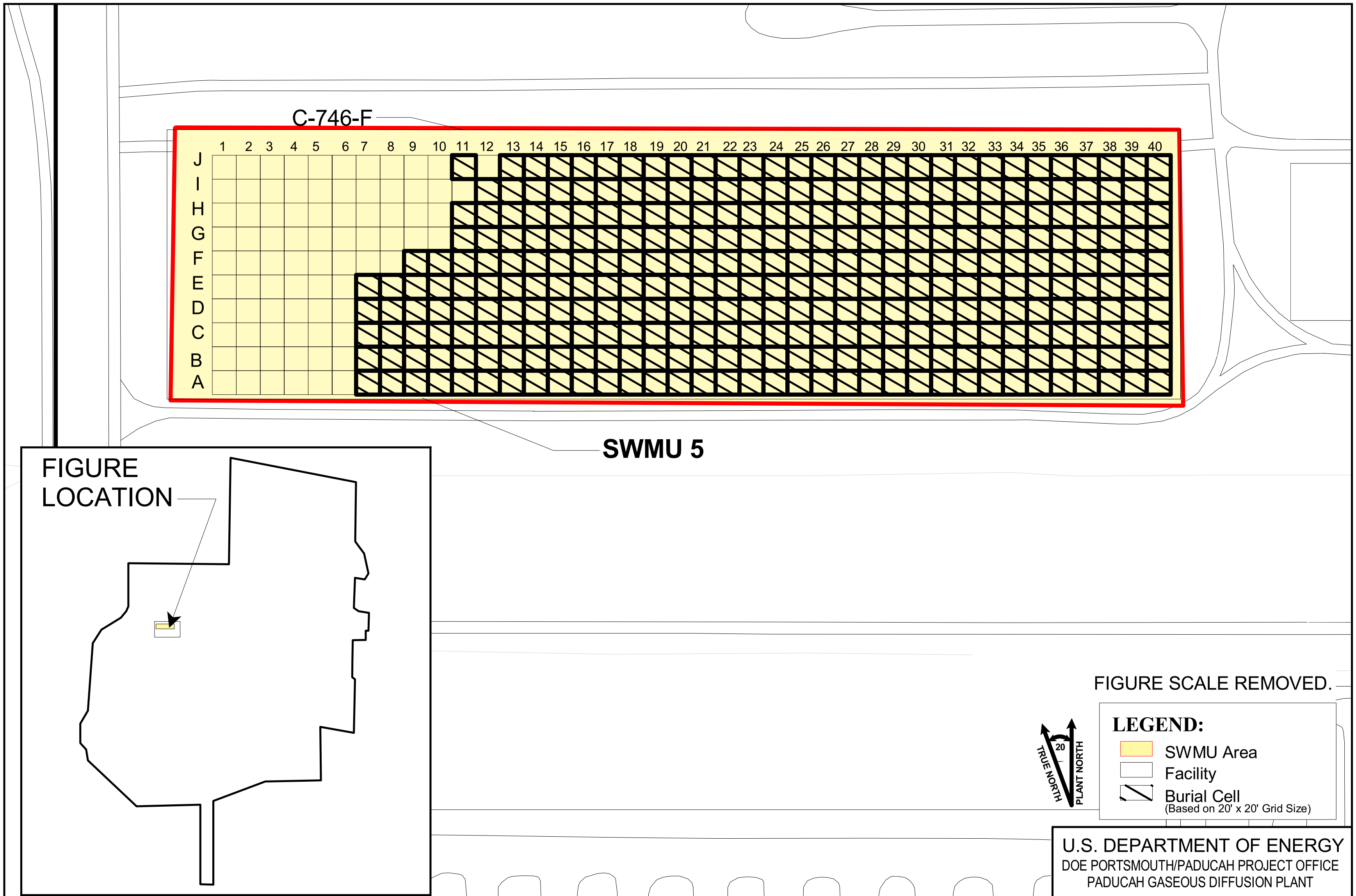

Figure 5.4. SWMU 5

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During the WAG 3 RI, a geophysical subsurface investigation was conducted to delineate the extent of burial/trench areas within SWMU 5. Both Electromagnetic (EM)-31 (responsive to soil conditions) and EM-61 (sensitive to metal) data were collected (DOE 2000c). The grid spacing for these geophysical surveys was 20 ft apart.

A good correlation among the methods was used to define the extent of the suspected burial/trench area in SWMU 5. The suspected burial area within this SWMU starts approximately 120 ft east of the western boundary of the SWMU through the eastern boundary of the SWMU. The extent is conclusive to the west and north (it appears to end at the gravel road), but inconclusive to the east and south because of cultural influences (e.g., the perimeter fence). Discrete, individual trench-like features are not apparent in the data. Anomalies detected in the northwest corner of the SWMU are believed to be near-surface metal and not associated with the burial ground operations.

5.1.4.2 Process history

SWMU 5 was in operation from 1965 to 1987. The burial pits were used for the burial of components from the "Work for Others" activities, some radionuclide-contaminated scrap metal, and slag from the nickel and aluminum smelters. Metals and radioisotopes are the primary potential contaminants of interest at this SWMU. The total quantity of wastes buried at the yard could be up to 896,000 ft^3, assuming an average quantity of 2,800 ft^3 waste placed in each cell, and 320 cells receiving waste. Chemically unstable or incompatible compound/metal wastes are thought to have been placed here also. This conclusion is supported by the occurrence of an underground fire (thought to have occurred circa 1975–1976) in the southeast corner of the yard. This fire burned for several weeks, and individuals observing the fire reported that the ground surface appeared to become unstable. The source and/or cause were never determined, and the fire extinguished itself without intervention. No data are available related to contaminant releases from the fire.

5.1.5 C-747-B Burial Ground (SWMU 6)

5.1.5.1 Area description

The C-747-B Burial Ground is located in the northwestern section of the plant area east of SWMU 5. SWMU 6 (Figure 5.5) was in operation from 1960 to 1976. The entire burial area covers an area of approximately 13,500 ft^2, which is divided into five separate burial cells (Areas H, I, J, K, and L). The following are the dimensions of each of the cells.

- Area H—This disposal site covers an area of about 12 by 15 ft and is about 6 ft deep. A 3 ft cover of soil was placed on top of the buried drums.

- Area I—This discard pit is approximately 8 by 35 ft and is about 8 ft deep. The waste was covered with about 5 ft of soil.

- Area J—This burial site is about 4,000 ft^2 (37 by 110 ft) and was excavated to a depth of about 6 ft. The area was covered with about 3 ft of soil.

- Area K—This disposal site consists of an area of about 12 by 15 ft and is about 6 ft deep. A 3 ft cover of soil was placed on top of the buried drums.

- Area L—This burial area is about 20 by 30 ft and about 6 ft deep. The disposed waste was covered with about 3 ft of soil.

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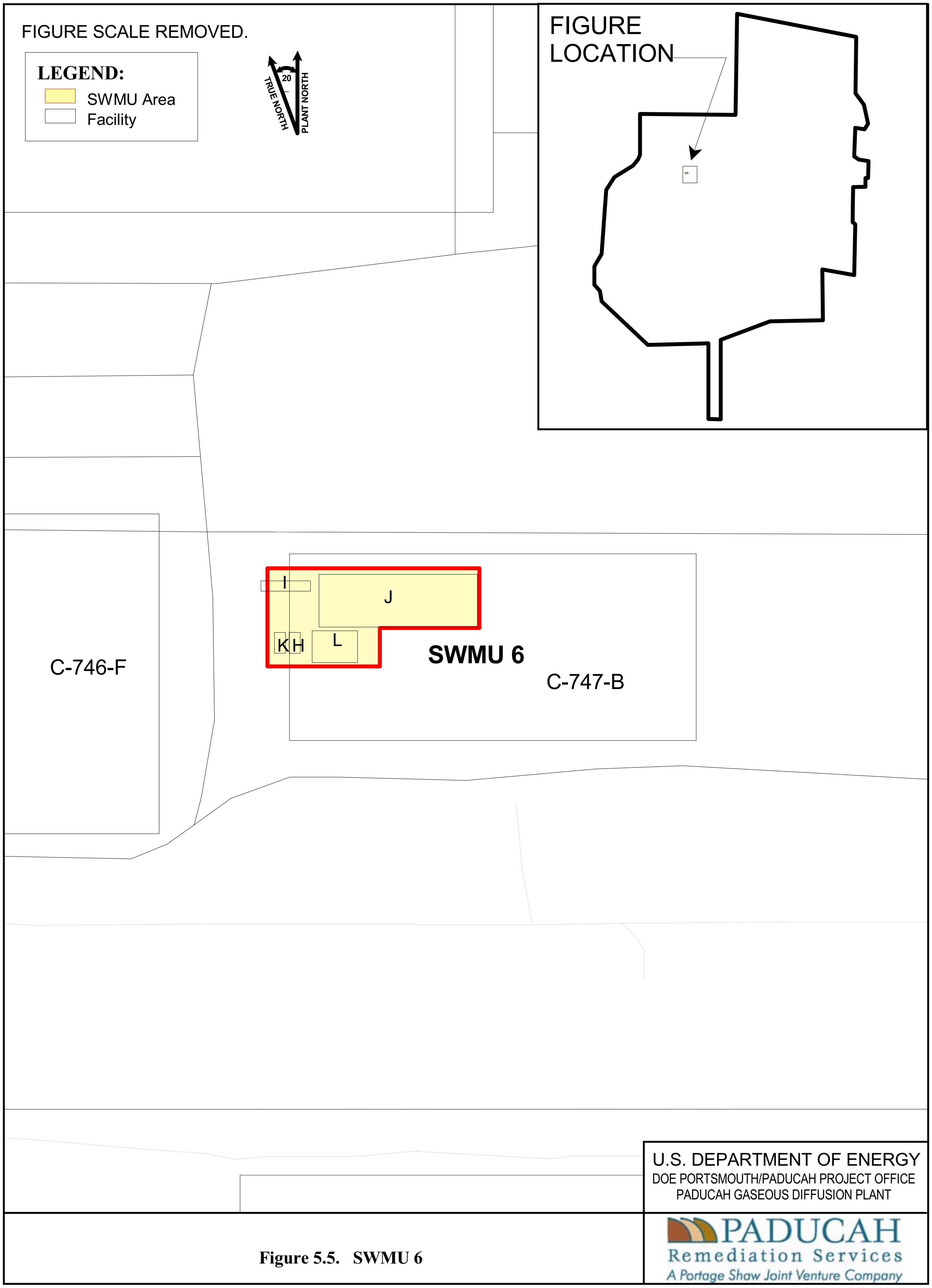

Figure 5.5. SWMU 6

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This area is relatively flat and is bounded to the north by a set of abandoned railroad tracks, to the east by a 5-ft-wide by 4-ft-deep drainage ditch that drains into Ditch 001, and unnamed gravel roads to the west and south. The ground surface is medium to tall grasses (up to 3 ft high) with occasional pockets of young trees and shrubs (DOE 1998c).

5.1.5.2 Process history

Each of the burial cells was used for the disposal of a different waste. Each cell and its contents were identified in the WAG 3 RI Report (DOE 2000c) as follows:

- Area H—Magnesium Scrap Burial Area. The scrap buried at this location is magnesium, in various shapes, generated in the machine shop. A total of about ten drums of scrap was buried during midsummer 1971.

- Area I—Exhaust Fan Burial Area. Eight exhaust hood blowers removed from C-710 were discarded to this pit. These blowers, which were about 15 in in diameter and weighed about 100 lb each, were discarded in 1966 because of contamination with perchloric acid. Each blower was spaced about 4 ft apart in the hole.

- Area J—Contaminated Aluminum Burial Area. The contaminated scrap buried in this hole involved about 100 to 150 drums of aluminum scrap in the form of nuts, bolts, plates, trimmings, etc., that were generated in the converter and compressor shop. This scrap was buried about 1960 or 1962.

- Area K—Magnesium Scrap Burial Area. The scrap buried at this location is magnesium in various shapes generated in the machine shop. A total of about 20 drums of scrap was buried on September 3, 1968, and December 23, 1969.

- Area L—Modine Trap Burial Area. A single contaminated modine trap was buried in this area. The cold trap was about 4 ft in diameter, approximately 15 ft long, and weighed about 5000 lb. This equipment was buried on March 5, 1969.

In the WAG 3 RI Report (DOE 2000c), it was stated that approximately 50% of the surface area of SWMU 6 has been used to store radioactively-contaminated equipment and materials. These items include industrial forklifts and transport carts, flatbed trailers, generators, concrete pipes, and other miscellaneous items. This equipment storage area was inaccessible during the investigation, except through the use of angle drilling and sampling techniques (DOE 2000c).

5.1.6 C-747-A Burial Ground (SWMU 7)

5.1.6.1 Area description

The C-747-A area is located in the northwest corner of the PGDP secured area. SWMU 7 (Figure 5.6) comprises the eastern two-thirds of C-747-A. The SWMU is bounded on the north and south sides by perimeter ditches, on the west side by the C-747-A Burn Area (SWMU 30), and on the east side by the C-746-E Contaminated Scrap Yard. SWMU 7 covers approximately 240,900 ft^2 and includes five discrete burial pit areas (Burial Pits B, C, D, F, and G) (DOE 1998d).

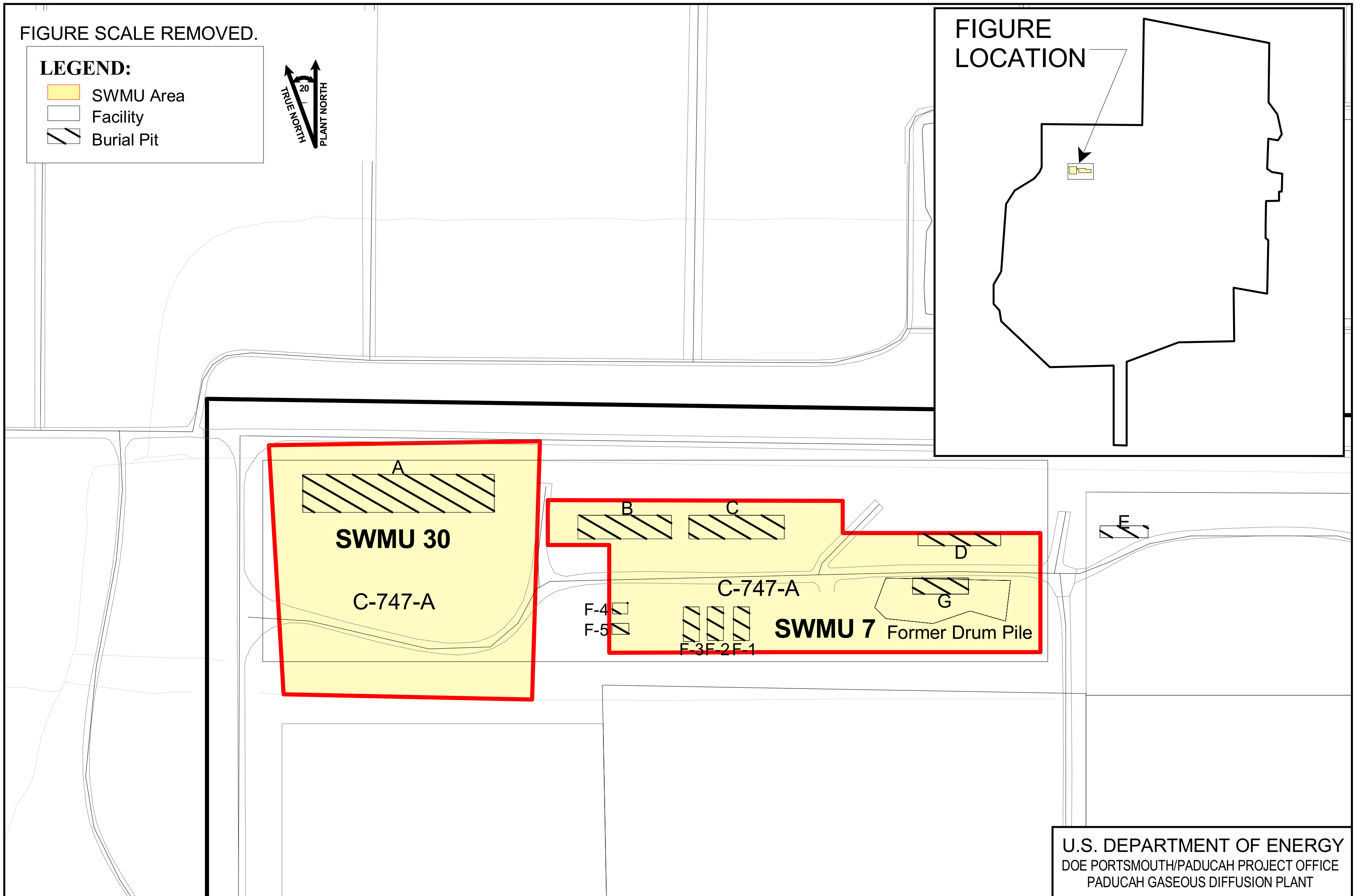

Figure 5.6. SWMUs 7 and 30

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Records indicate the burial pits were excavated to a depth of 6 to 7 ft bgs, filled with wastes, and covered with approximately 3 ft of earth; however, the Phase II SI discovered waste to a depth of 10 ft on the west side of Burial Pit B, and borings sampled waste to a minimum depth of 8 ft in Burial Pit C (Union Carbide 1978). A stockpile of radiologically-contaminated scrap drums, locally known as Drum Mountain, formerly was located on the southeast corner.

The land surface slopes within SWMU 7. Burial Pits B and C form a slight hill on the north side of SWMU 7, and Burial Pit F forms a lesser mound on the south side of the SWMU. Pit D underlies a level area north of where Drum Mountain was once located. Shallow drainage swales occur on the west side of Burial Pit B and between Burial Pits C and D. The ground surface is covered by grassy vegetation, except where gravel roads extend through the site.

Henry silt loam is the predominant soil type at SWMU 7. The Henry soil series contains poorly drained, acidic soils that have a fragipan. This type of soil usually is formed in loess or alluvium. This fragipan layer is likely to remain intact, exclusive of the immediate burial pit area. Henry soils typically have moderate permeability above the fragipan and low-permeability within the fragipan. Permeability in the fragipan is less than 0.4 ft/day (DOE 1998d). During the Phase II Investigation, double-ring infiltrometer tests were conducted on surface soils at SWMU 7. Average long-term infiltration rates ranged from less than 5.7 ft/day) (CH2M HILL 1992).

The upper 20 ft of soils at SWMU 7 consist of surface soil, fill, and loess, alternatively described as silt or clay, in the area boreholes. Surface soils, to a depth of 6 in., were sampled and described during the Phase II SI. Soil textures range from sand with gravel to lean clay with gravel. Logs of deeper soil borings demonstrate that coarse textures generally are limited to the upper 2 ft, with the exception of the burial pits that are now known to be as much as 10 ft deep.

The surface water that drains from SWMU 7 into the surrounding ditches is carried west through Outfall 001 into Bayou Creek. In 2002, a sedimentation basin was constructed to contain runoff from PGDP scrap yards. Runoff now flows into the sedimentation basin and is released periodically into Outfall 001.

5.1.6.2 Process history

PGDP used the burial pits for disposal of wastes from 1957 to 1979. Burial Pits B, C, and G were used for disposal of noncombustible, contaminated and uncontaminated trash, material, and equipment. Contaminated concrete removed from the C-410 Feed Plant during May and June 1960 was placed in Burial Pits D and E. Burial Pit F was used for disposal of uranium-contaminated scrap metal and equipment. Empty uranium and magnesium powder drums also were reported to have been buried in Burial Pit F (Union Carbide 1978).

The following summarizes what is known about the size and disposed waste in the burial pits.

- Pit B (SWMU 7)—This pit is approximately 60 by 172 ft. Buried material includes noncombustible trash and contaminated and noncombustible material and equipment. According to the Phase II SI geophysical survey, the actual excavation extends beyond the designated boundaries and may connect with the adjacent burial pit (Pit C).

- Pit C (SWMU 7)—This pit is approximately the same size as Pit B. Based on the Phase II geophysical survey, Pit C and Pit B may be one continuous pit. Historic records indicate that both Pit B and C received the same material.

- Pit D (SWMU 7)—This pit is approximately 15 by 99 ft. Documented buried material consists of uranium-contaminated concrete pieces of reactor tray bases from C-410 used during the fluorination process of uranium tetrafluoride to uranium hexafluoride.

- Pit E (outside the eastern boundary of SWMU 7 and within the C-746-E Contaminated Scrap Yard)—This pit is approximately 15 by 143 ft. Documented buried material consists of uranium-contaminated concrete pieces of reactor tray bases.

- Pits F1-F5 (SWMU 7)—These five pits are all small (approximately 20 by 80 ft). Documented buried material consists of uranium-contaminated scrap metal and equipment and empty uranium and magnesium powder drums.

- Pit G (SWMU 7)—This pit is approximately 27 by 122 ft. Documented buried material consists of noncombustible trash and contaminated and noncombustible material and equipment.

In addition to these burial pits, the Phase II SI geophysical investigation also identified another anomaly in the shape of a rough circular area (15 ft) between SWMU 30 and SWMU 7, northwest of the F-4 and F-5 Pits. There is no information confirming the presence or the nature of any buried wastes associated with this anomaly.

5.1.7 C-747-A Burn Area (SWMU 30)

5.1.7.1 Area description

SWMU 30 (Figure 5.6) includes the western one-third of C-747-A. It consists of an historical burn-and-burial pit (Burial Pit A) and the location of a former incinerator. The SWMU is bounded on the north and south sides by ditches, on the west side by Patrol Road, and on the east side by C-747-A Burial Ground (SWMU 7). The unit encompasses approximately 128,000 ft^2. The pit is reported to have been excavated to a depth of 12 ft and covered with 4 ft of earth. The land surface slopes gently, and a slight mound rises over Burial Pit A. SWMU 30 is bordered by drainage ditches on the north and south side. Grassy vegetation covers the ground, except where gravel roads extend through the site.

The soil survey of McCracken County maps Henry soil loam across SWMU 30. However, all deeper soils borings, including Phase II SI borings H-211 and H-212, MW 66, and boring S-2, encountered surficial fill materials to depths of 2 to 12 ft. Phase II surface soil sample sites H-361 through H-366, H-370, and H-373 provide characterization of surface soil texture from eight locations across SWMU 30. The upper 6 in. of soil ranges from lean clay to sand. Surface soil samples from the Burial Pit A area tend to be lean clay with gravel, whereas, surface soil textures from the south side of SWMU 7 range from lean clay to silty sand with gravel (DOE 1998d).

The Phase II SI included double-ring infiltrometer tests on surface soils at three locations. Average long-term infiltration rates were less than 6×10^{-3} ft/day for two of the tests.

5.1.7.2 Process history

SWMU 30 was used from 1951 to 1970 to burn combustible trash, which may have contained uranium contamination. Ash and debris were buried below ground in Burial Pit A beginning in 1962, when use of an on-site incinerator was discontinued. Site maps and a surface electromagnetic geophysical survey of the Phase II SI identify the location of Burial Pit A. Prior to identification by Phase II SI surface geophysics testing, it was believed that remnants of the former incinerator were not present. Further research identified images of the incinerator at the location. This disposal site covers an area of about 250 by 50 ft. Geophysical data from the Phase II SI indicate that the actual area of excavation does not exactly match the rectangular outline, and extends beyond the rectangular outline to the north and east. Material disposed in Pit A included contaminated and uncontaminated trash, ash, and debris.

In addition to Pit A, the Phase II SI geophysical investigation also identified another anomaly in the shape of a rough circle approximately 43 ft in diameter. There is no information confirming the presence or the nature of any buried wastes associated with this anomaly.

5.1.8 Area P (SWMU 145)

5.1.8.1 Area description

Area P (SWMU 145 – Figure 5.7) is located north of the PGDP security area and is defined by encompassing SWMUs 9 and 10 (the C-746-S&T Landfills, respectively). The SWMU is approximately 44 acres and began operation in the early 1950s. Currently, the C-746-S&T Landfills are located on top of SWMU 145 (DOE 1999b). The boundaries of the area are not well defined outside of the area utilized by the C-746-S&T Landfills.

5.1.8.2 Process history

SWMU 145 began operation in the early 1950s. A 1973 document *The Discard of Scrap Materials by Burial at the Paducah Plant* (Union Carbide 1973), states this area was used by the contractor during the construction of PGDP to discard all types of scrap and waste materials. Use of the area for discarding of scrap and waste by subcontractors was continued until the early 1980s. Construction debris, such as concrete, roofing materials, wire, wood, shingles with asbestos, and welding rods are expected to have been disposed of in the area. Approximately once a year, the accumulated scrap piles were moved by plant personnel into piles or earth depressions and, whenever practicable, covered with dirt. The area was later permitted for the construction and operation of the C-746-S & T Landfills (BJC 2001).

5.2 PREVIOUS ANALYTICAL DATA

5.2.1 Soils

5.2.1.1 SWMUs 2 and 3

Figure 5.8 shows 12 subsurface soil sampling data points around SWMU 2 associated with the historical OREIS data set described at the beginning of this chapter. Generally, most contaminants were found at, or near, background levels. Figures 5.9 and 5.10 show TCE and arsenic levels found in the soils around SWMU 2. TCE was detected in boring SWMU2-2 at 140 mg/kg. TCE was not detected in surface soil and only in three additional subsurface soil locations (SWMU2-12, SWMU2-8, and SWMU2-9) at levels of 0.28 mg/kg, 0.01 mg/kg, and 0.0078 mg/kg, respectively.

There are no soil sample data in the OREIS data set associated with SWMU 3.

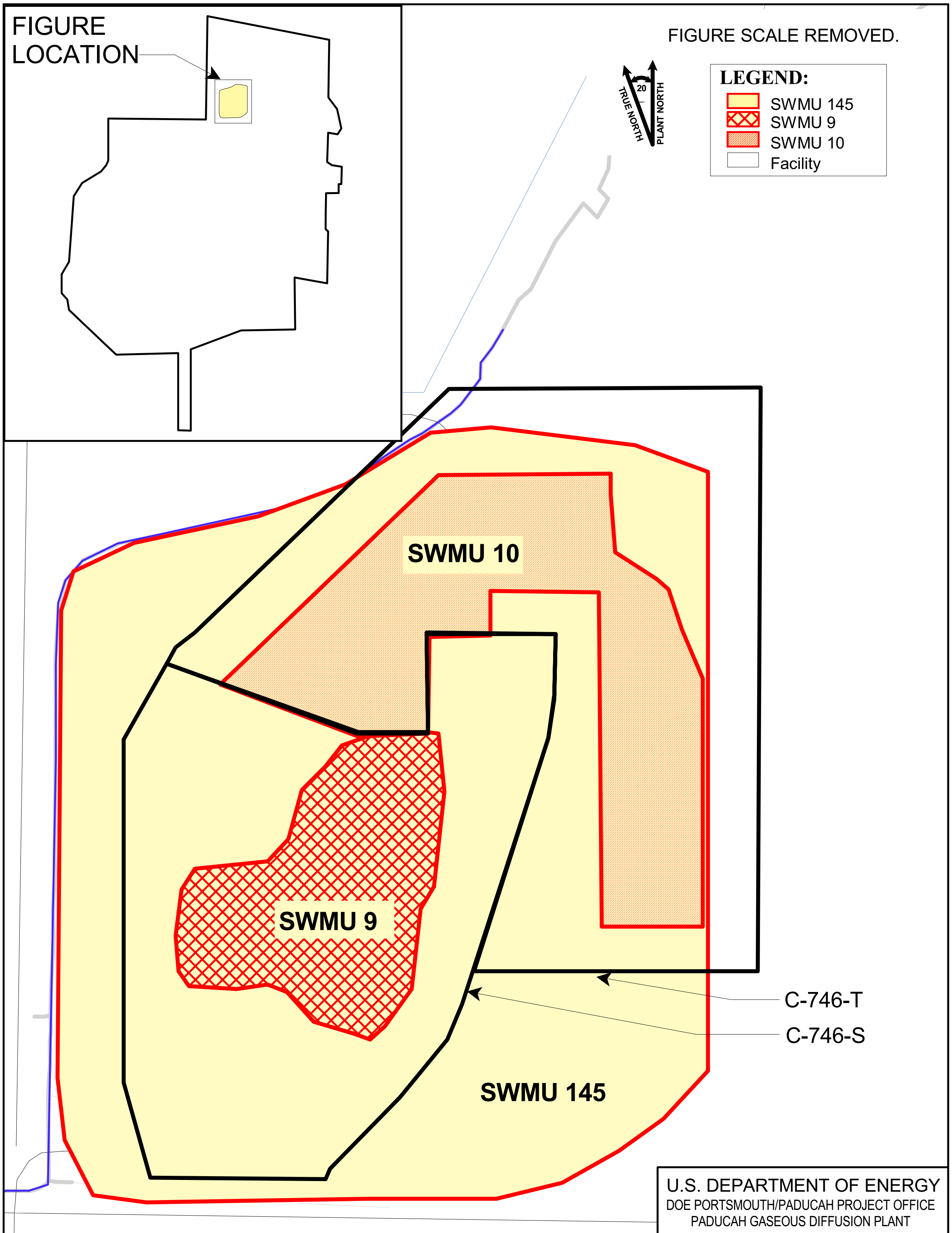

Figure 5.7. SWMU 145

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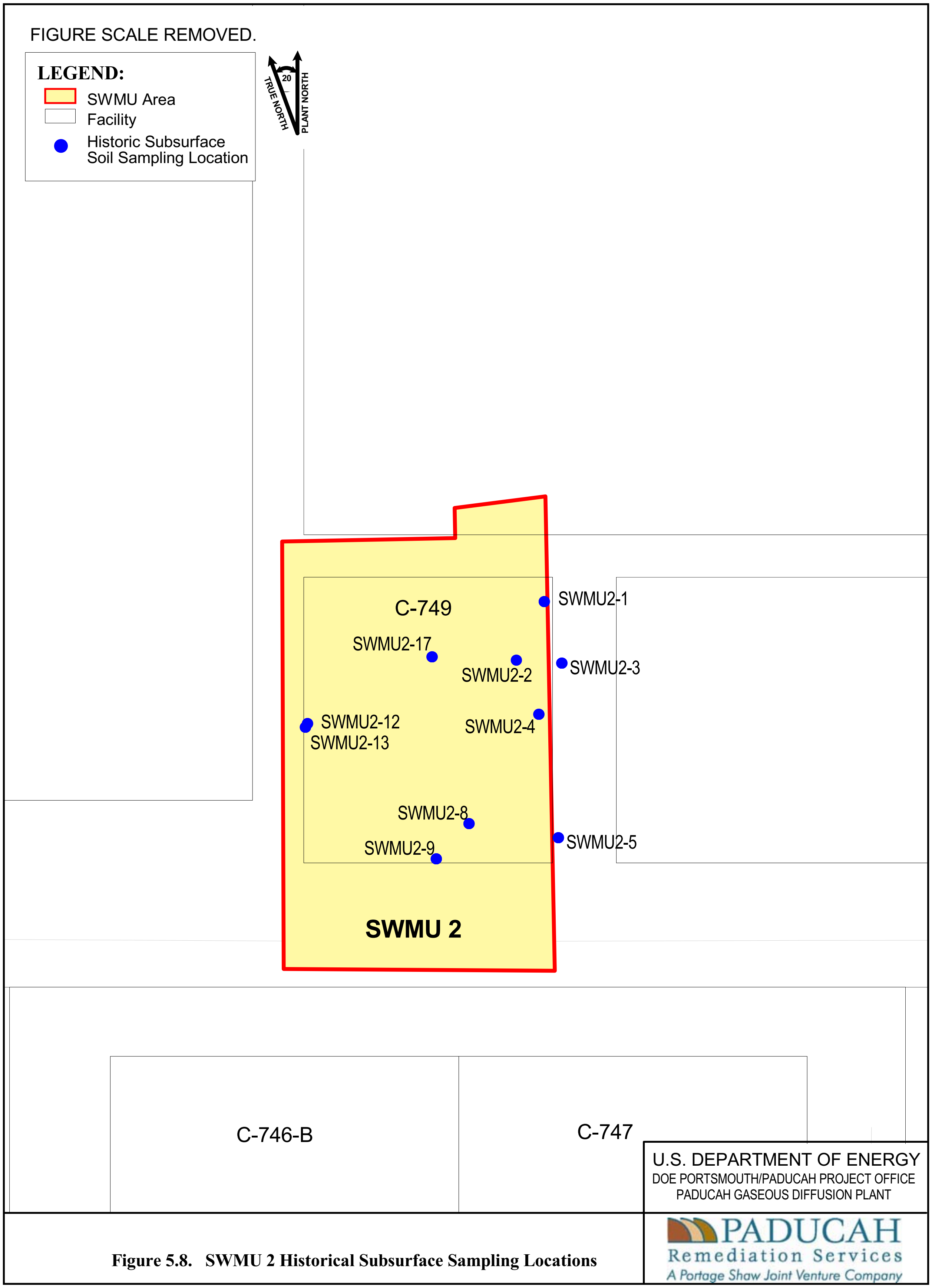

Figure 5.8. SWMU 2 Historical Subsurface Sampling Locations

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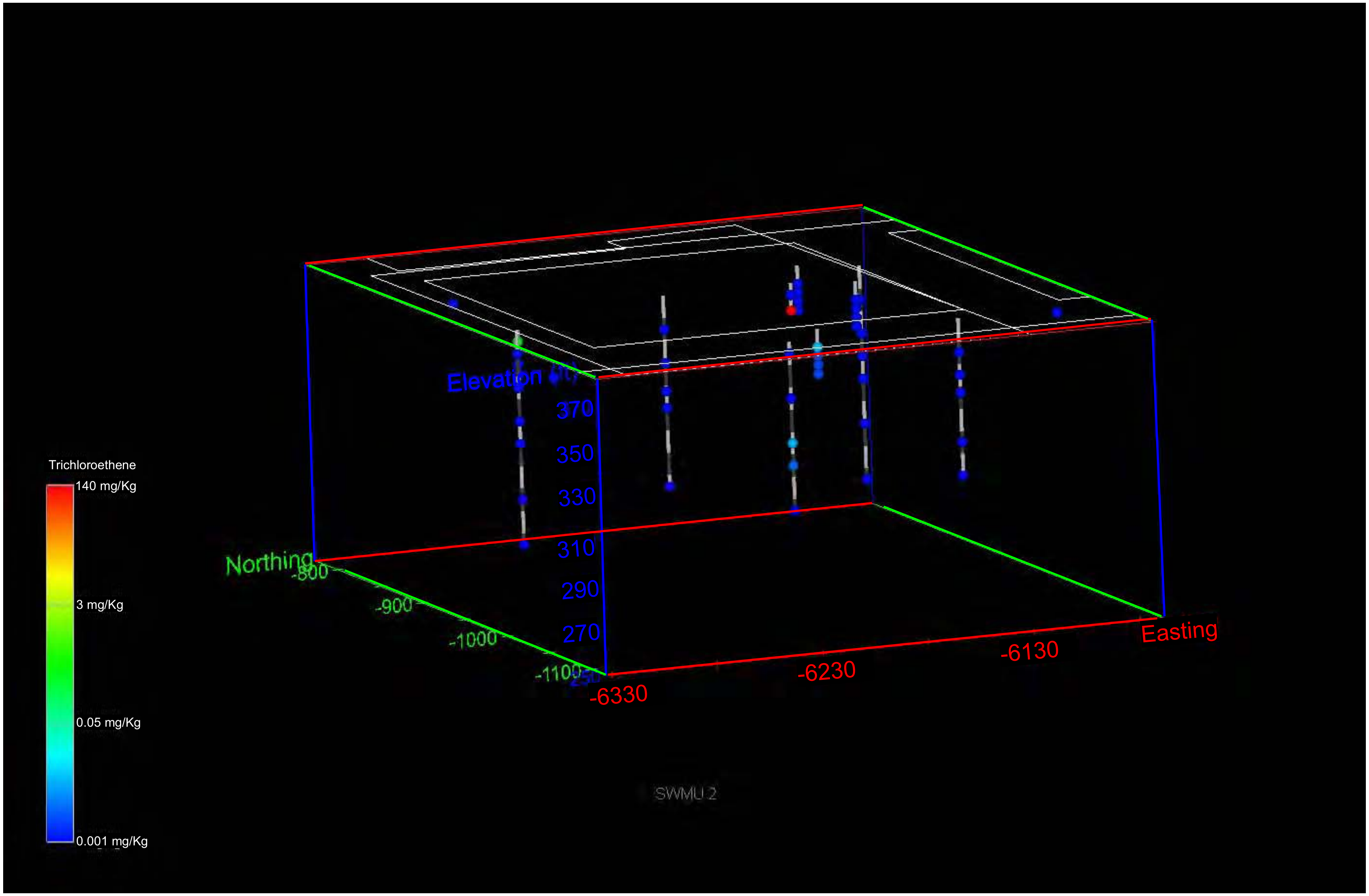

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Fig. 5.9. SWMU 2 TCE in soil.

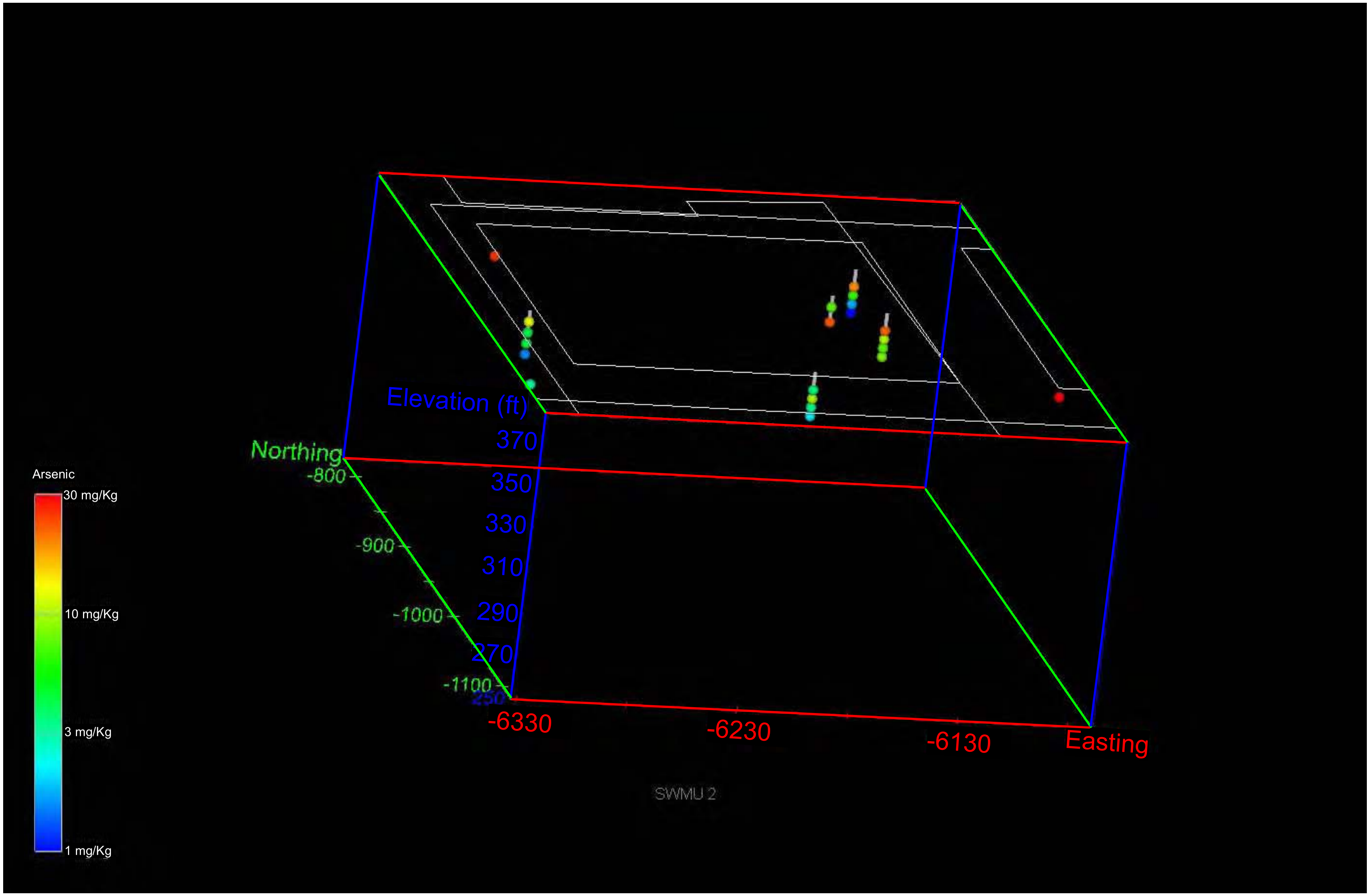

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Figure 5.10. SWMU 2 Arsenic in Soil

5.2.1.2 SWMU 4

Figure 5.11 shows the 47 soil sampling data points around SWMU 4 associated with the historical OREIS data set described at the beginning of this chapter. Figures 5.12 through 5.21 show various contamination levels found in soils around SWMU 4. The highest detected levels for TCE (41 mg/kg) located in boring 004-022 is above the Industrial Work Risk-Based No Action Level.

SWMUs 4, 5, and 6 were investigated as part of an RI Report prepared for WAG 3 in 2000 (DOE 2000b). Prior to the WAG 3 investigation, SWMU 4 was investigated in 1992 (CH2M HILL 1992); however, no groundwater samples were collected as part of this SWMU 4 investigation. The WAG 3 RI Report concluded that volatiles are present in the subsurface soil, UCRS groundwater, and RGA groundwater at SWMU 4. The majority of VOCs detected were TCE and its degradation products.

Contaminants at SWMU 4 are buried in several burial cells of varying size to a depth of approximately 16 ft bgs. Some of these contaminants may have leached out of the burial cells and into the underlying soils and groundwater. These contaminants include TCE and degradation products and various radiological contaminants. PCBs are found at shallow depths, 3 to 6 ft bgs, and may be the result of waste handling practices.

Limited data within the burial cells were collected due to the high hazards (both chemical and radiological) that were encountered. The few samples collected indicated the presence of radiological contaminants, PCBs, and various VOCs.

Radiological contamination is also widespread in SWMU 4. Alpha activities up to 3076.71 pCi/g and beta activities up to 3253.97 pCi/g are present. Measured radioisotopes, including total uranium (up to 6260 pCi/g), ^{99}Tc (up to 269 pCi/g), and ^{239}Pu (up to 4.17 pCi/g) are found in the surface and subsurface soils, and in the shallow groundwater.

Uranium was found in boring 004-030 at a depth from three to six ft measuring 6260 pCi/g. All other uranium results were detected at least two orders of magnitude lower. Uranium was found in an angle boring at 16 ft measuring 8.64 pCi/g and at 46 ft measuring 2.33 pCi/g. No uranium was detected at depths between 46 and 71 ft. The highest level of uranium-235 was at 11 ft measuring 4.2 pCi/g in boring 004-042. The environmental transport of uranium is strongly influenced by its chemical form. Uranium preferentially adheres to soil particles, with a soil concentration typically about 35 times higher than that in the interstitial water (the water between the soil particles); concentration ratios are usually much higher for clay soils.

PCBs were detected in surface soils (ditches) and the shallow subsurface soils at SWMU 4. All of the samples with concentrations above screening levels are contained within an area from surface to 11 ft bgs.

Associated chemical and physical properties of the source areas consist of various industrial wastes and soil backfill in the burial cells, and sands, silts, and clays of the UCRS in the remainder of the SWMU. The entire SWMU is covered with a cap consisting of approximately 3 ft of soil with a vegetative cover (DOE 2000c).

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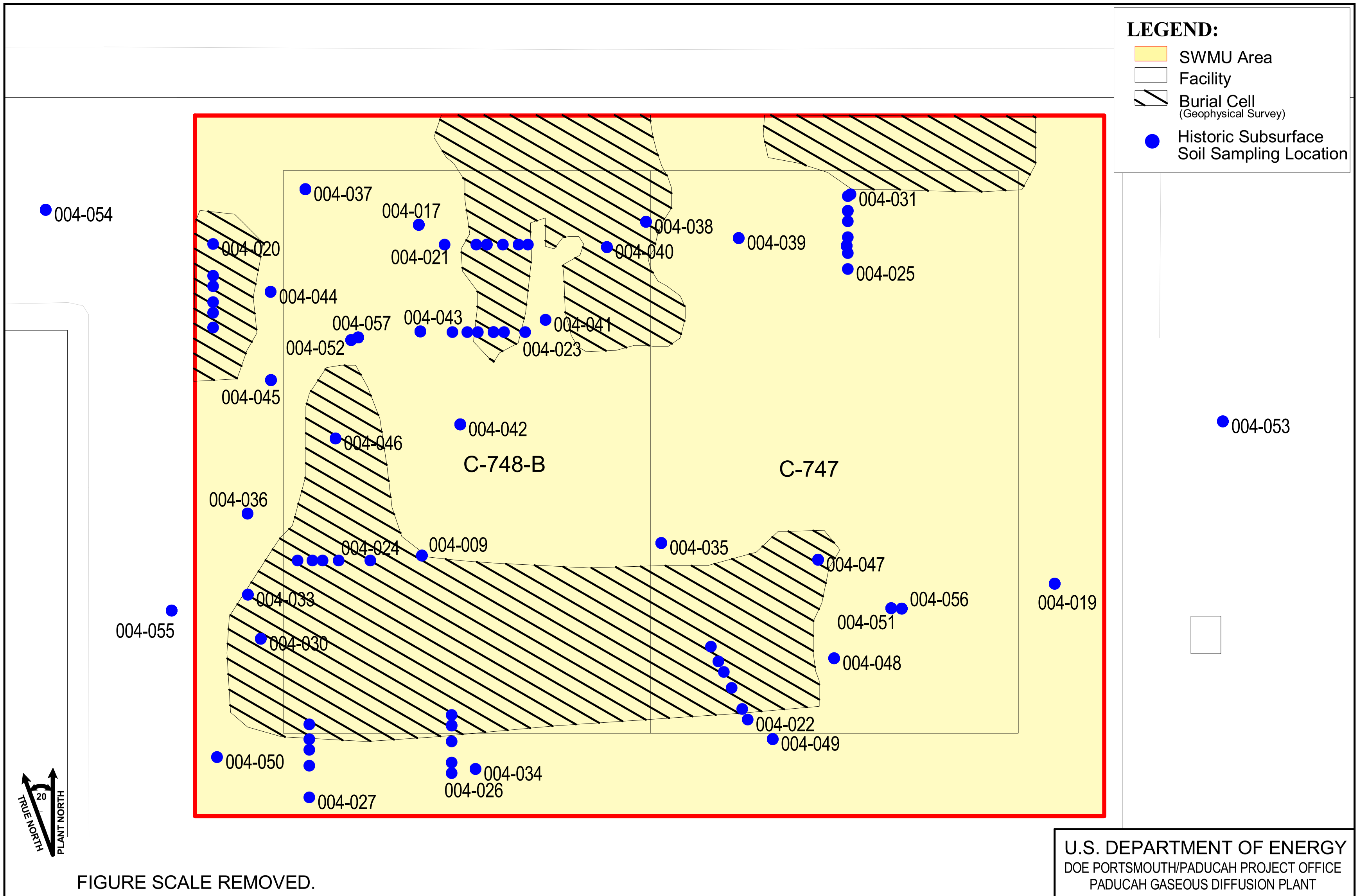

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Figure 5.11. SWMU 4 Historical Subsurface Soil Sampling Locations

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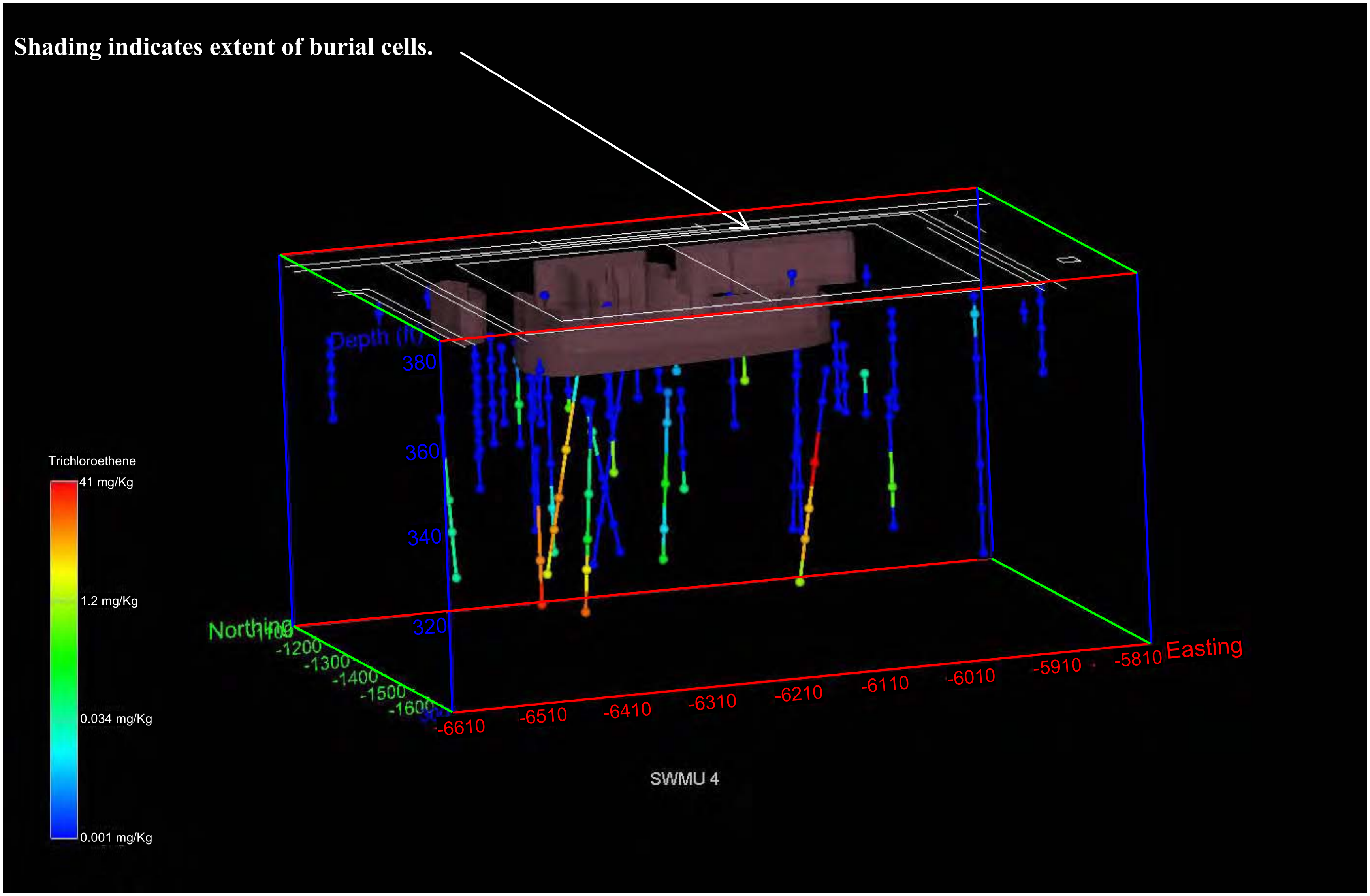

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Figure 5.12. SWMU 4 TCE in Soil

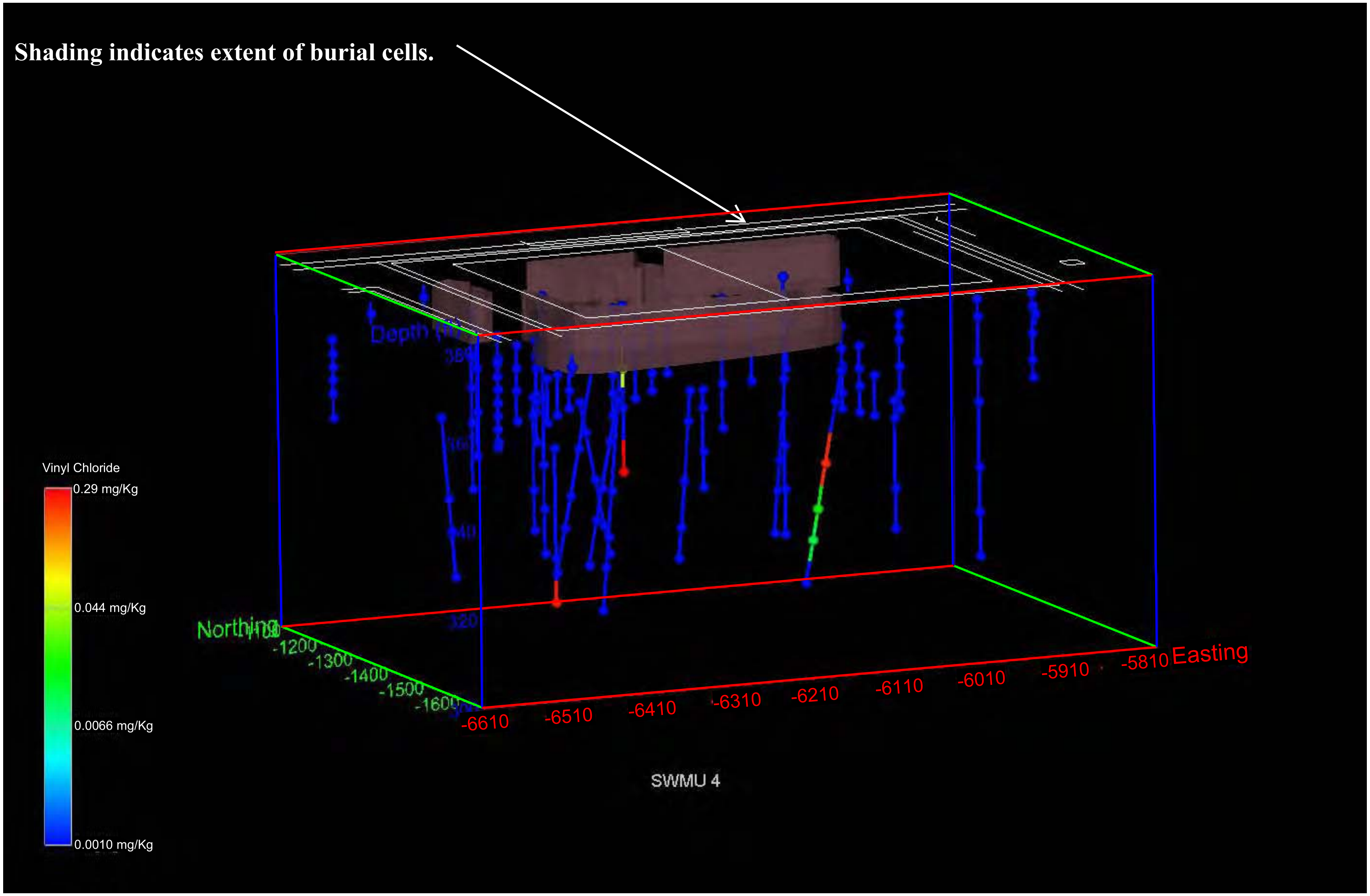

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Figure 5.13. SWMU 4 Vinyl Chloride in Soil

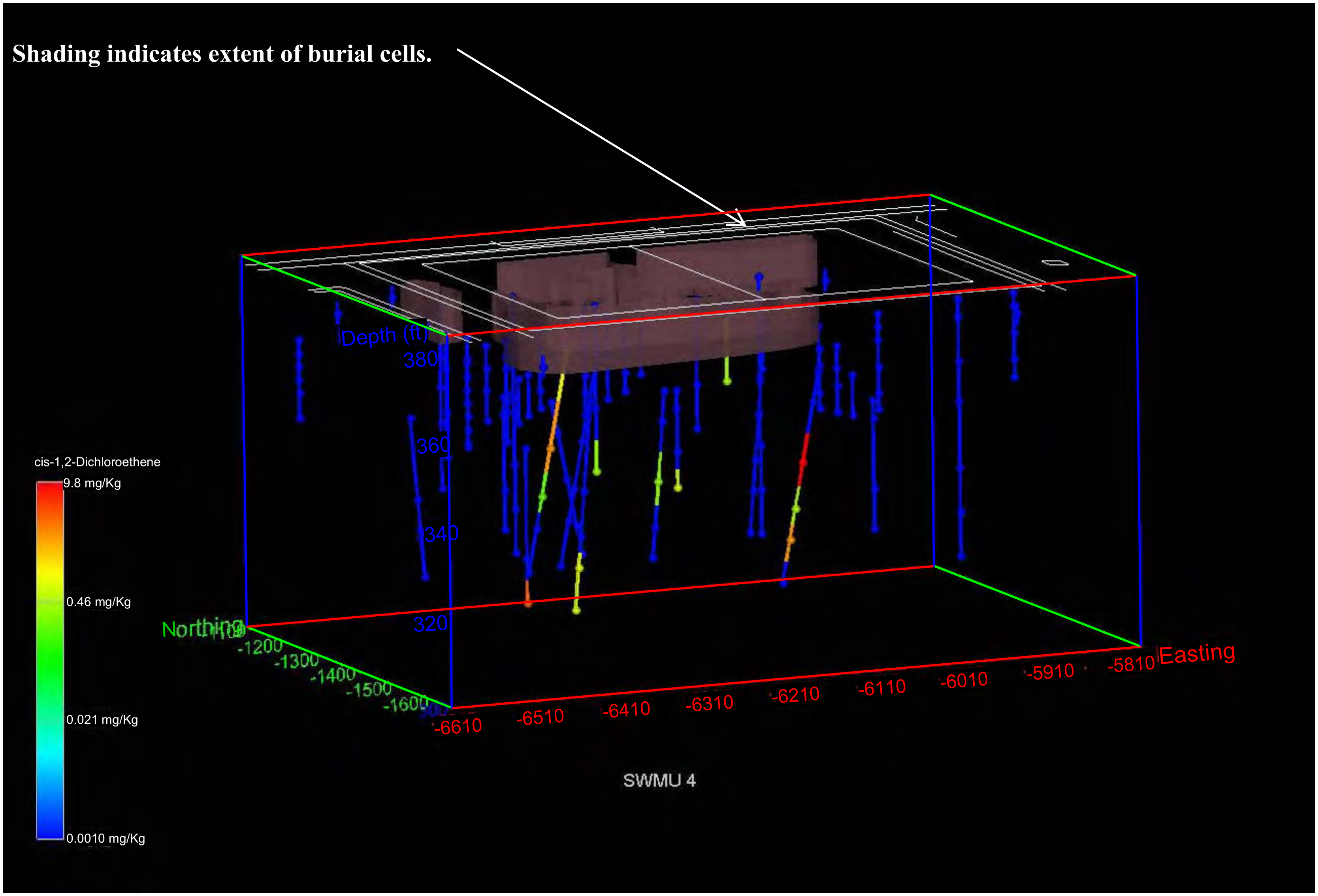

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Figure 5.14. SWMU 4 1,2-Dichloroethene in Soil

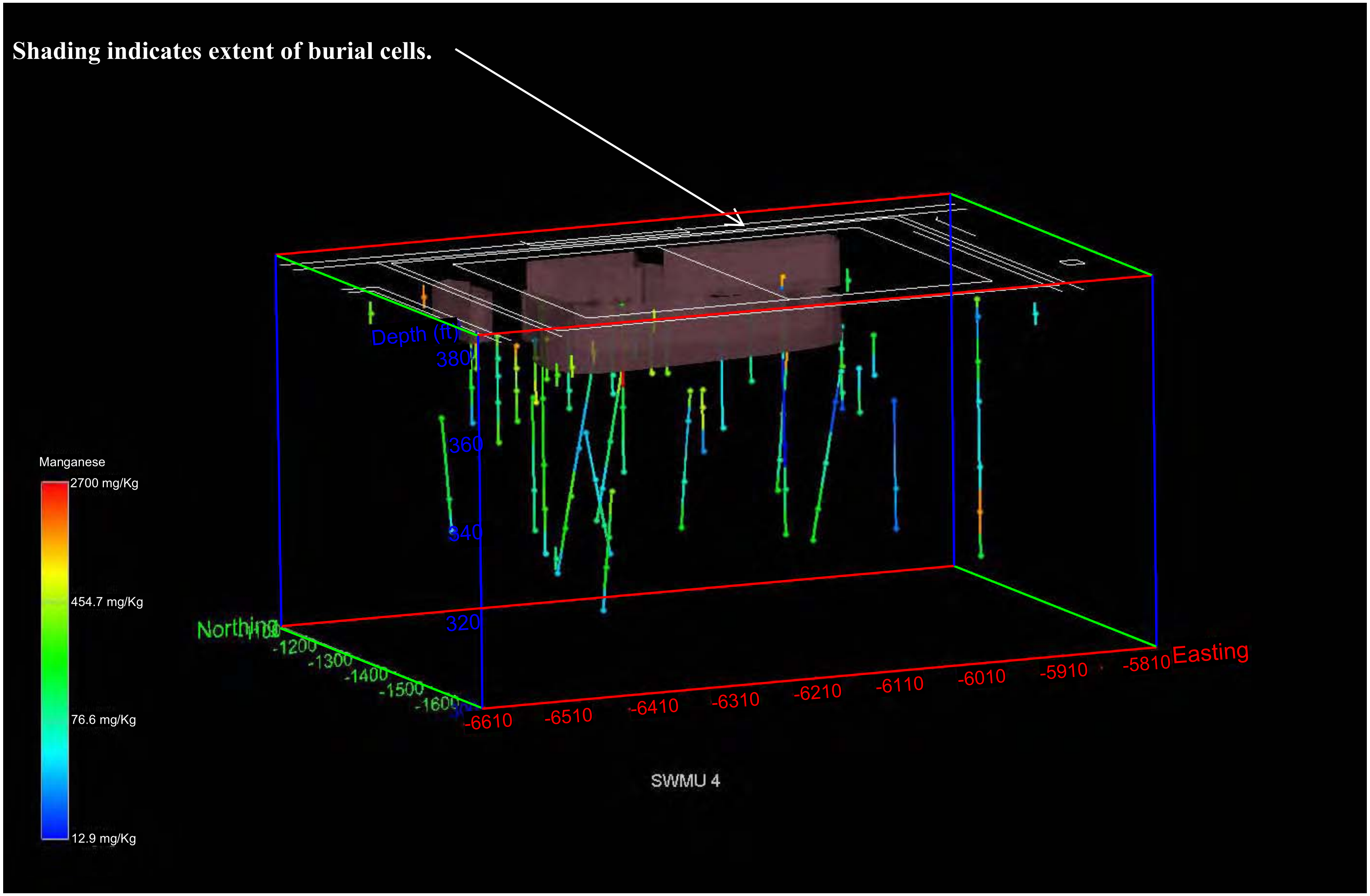

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Figure 5.15. SWMU 4 Manganese in Soil

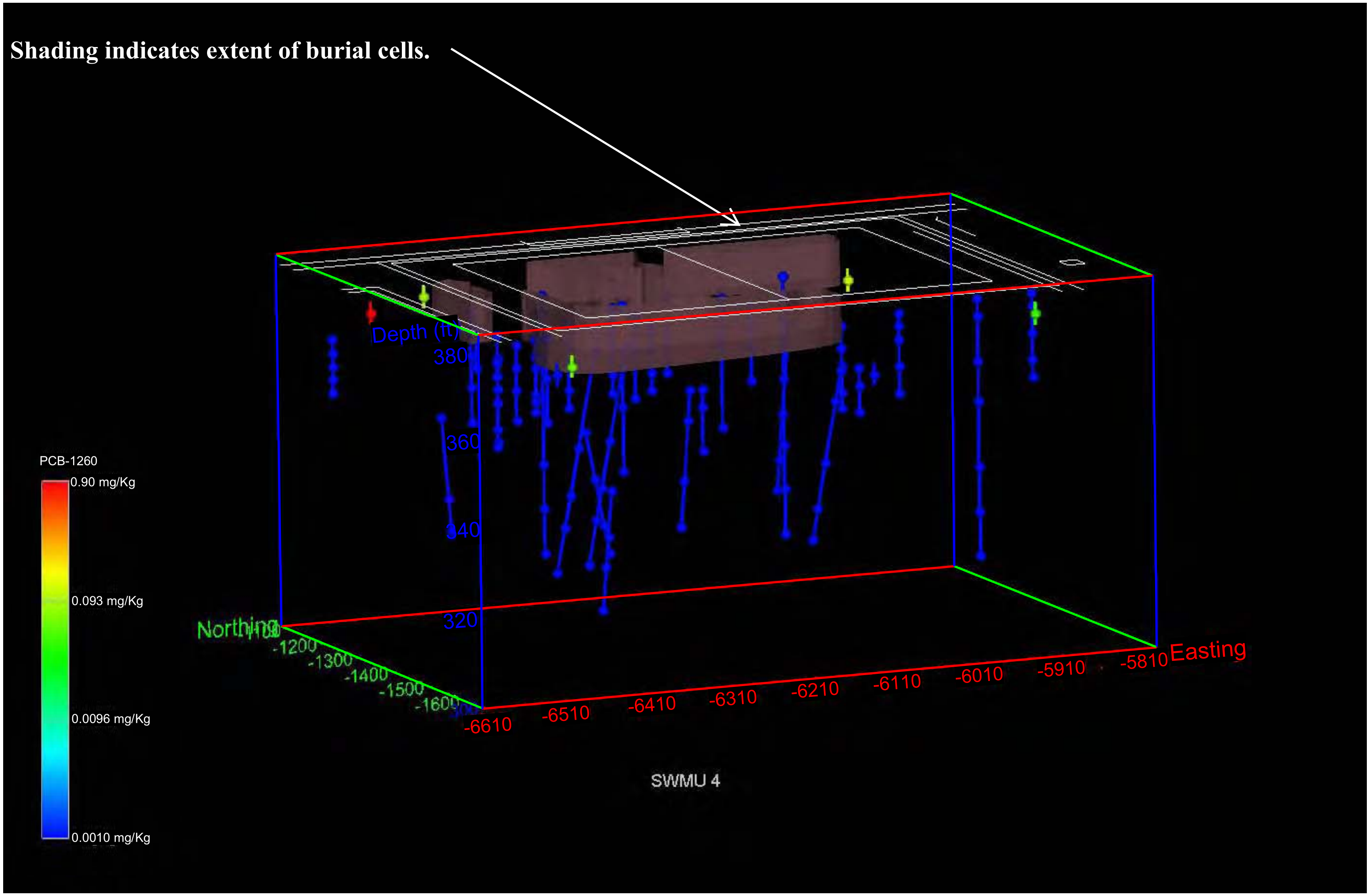

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Figure 5.16. SWMU 4 PCB-1260 in Soil

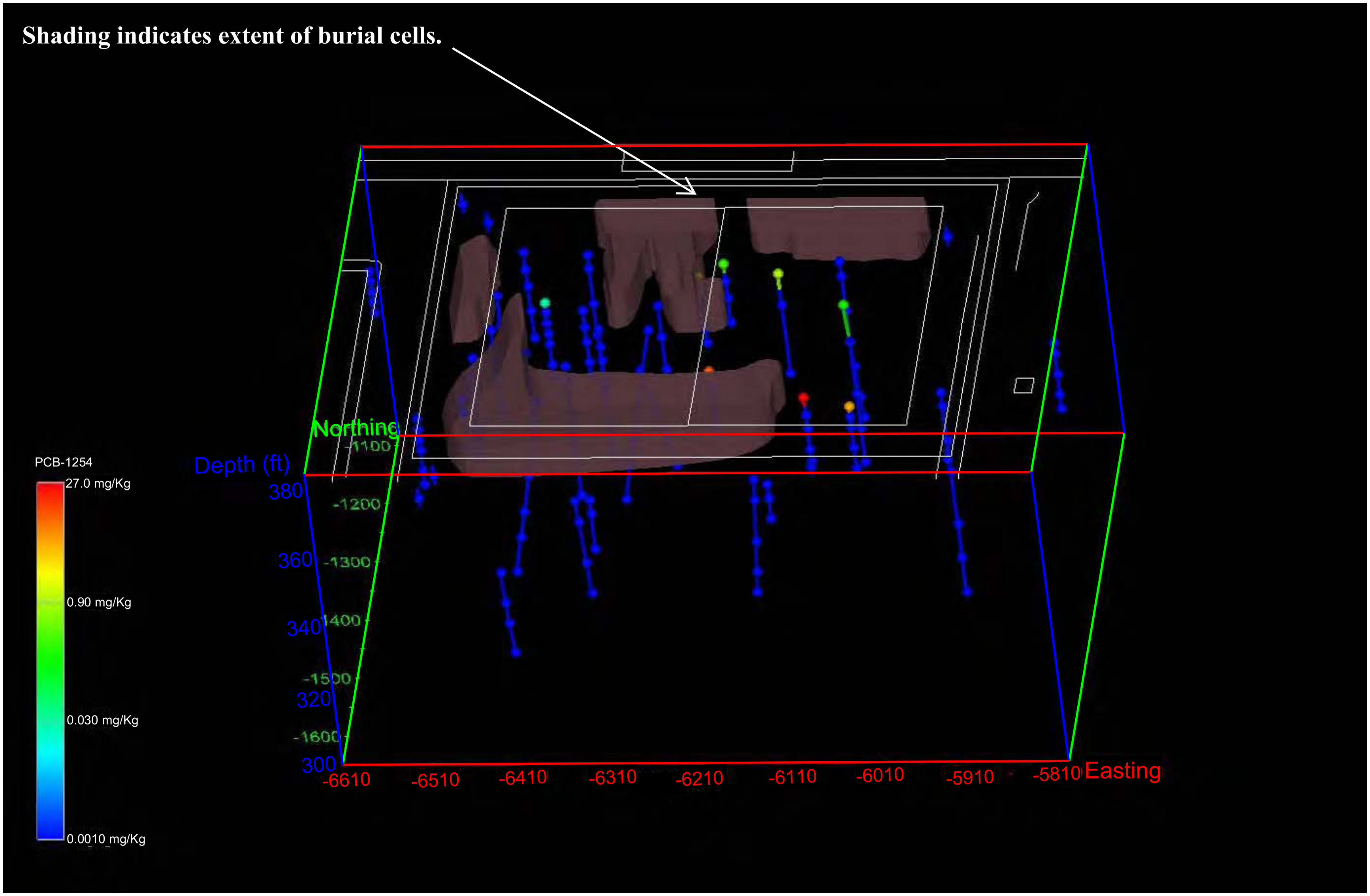

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Figure 5.17. SWMU 4 PCB-1254 in Soil

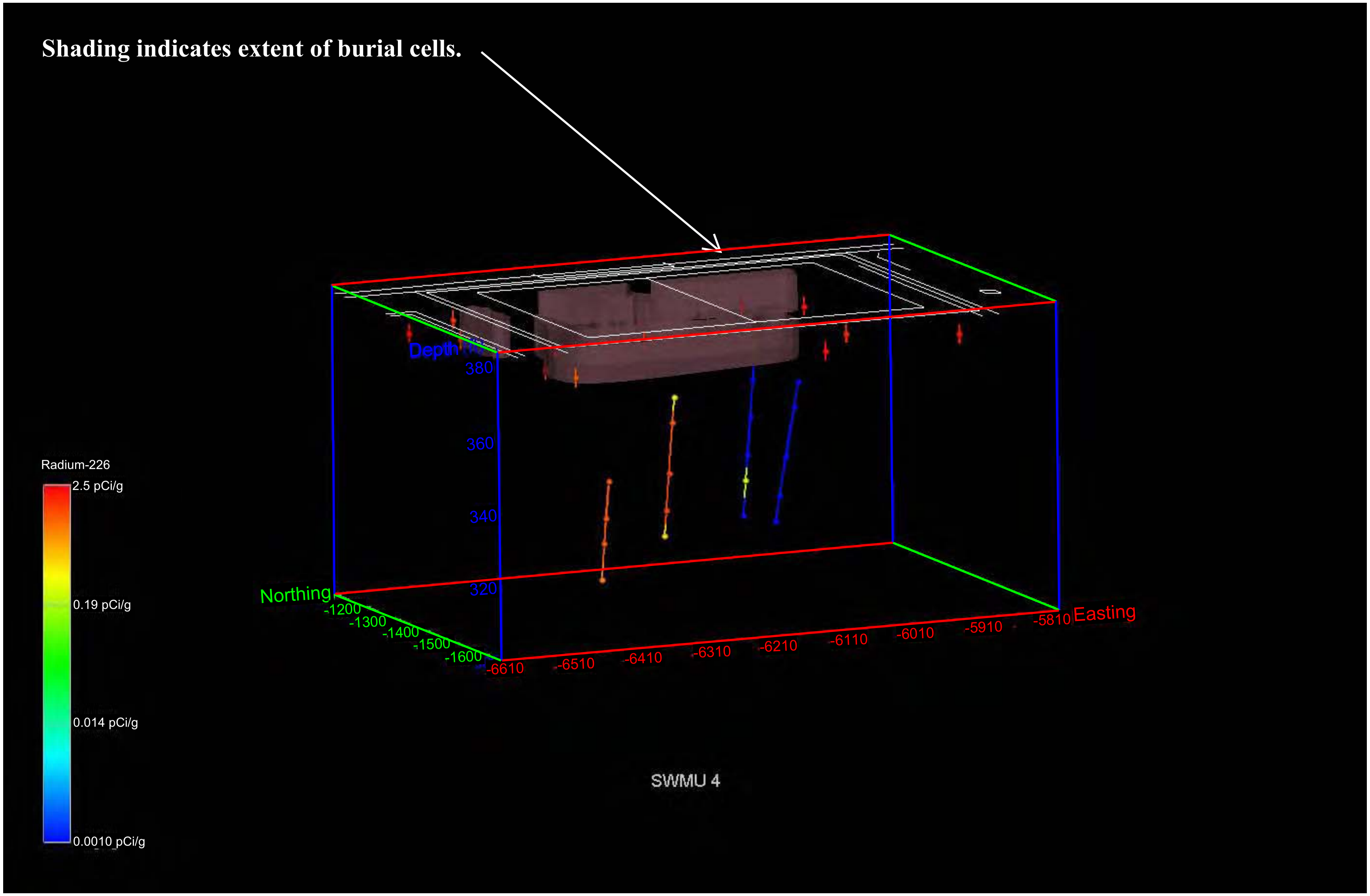

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Figure 5.18. SWMU 4 Radium-226 in Soil

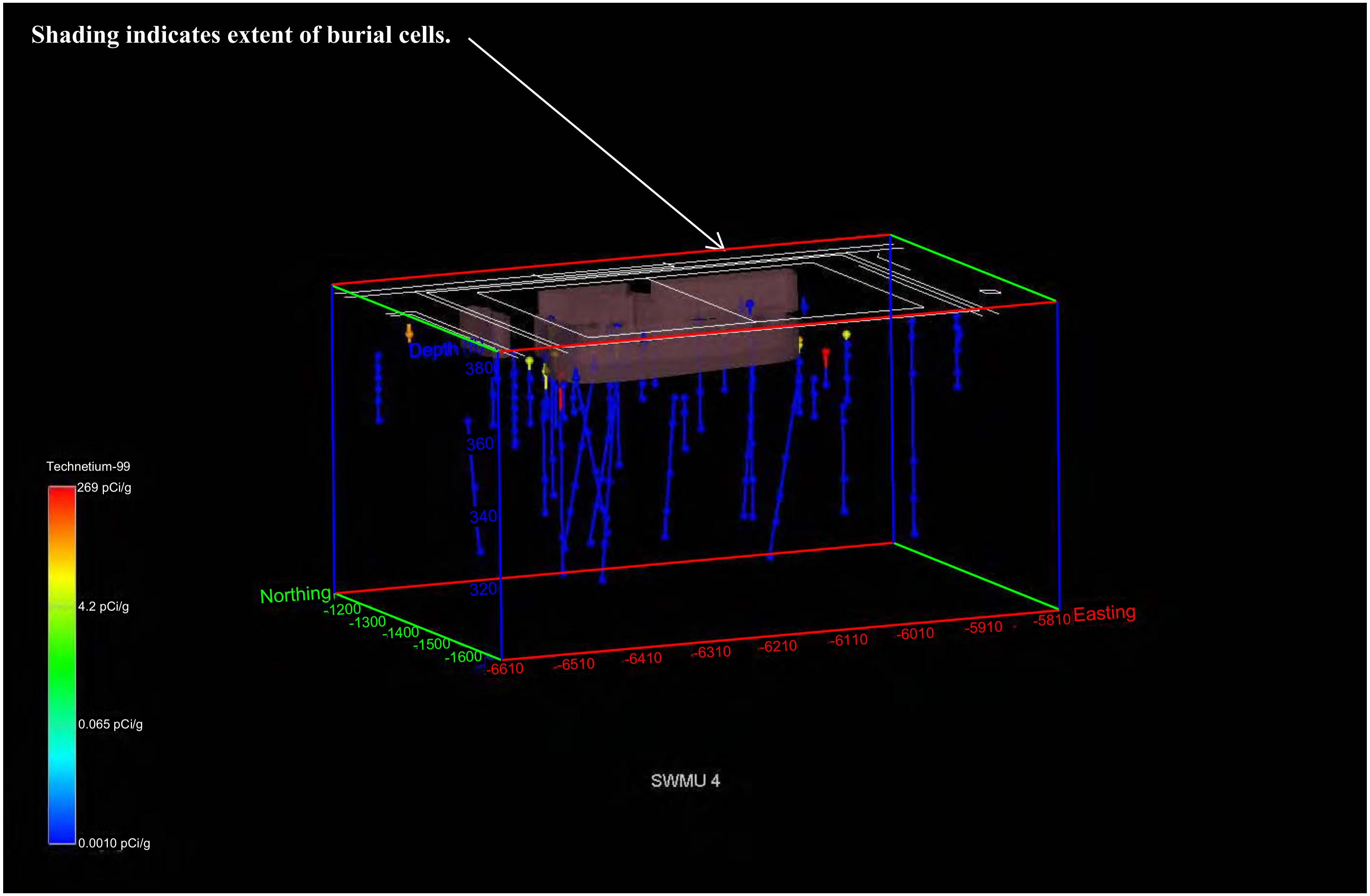

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Figure 5.19. SWMU 4 Technetium-99 in Soil

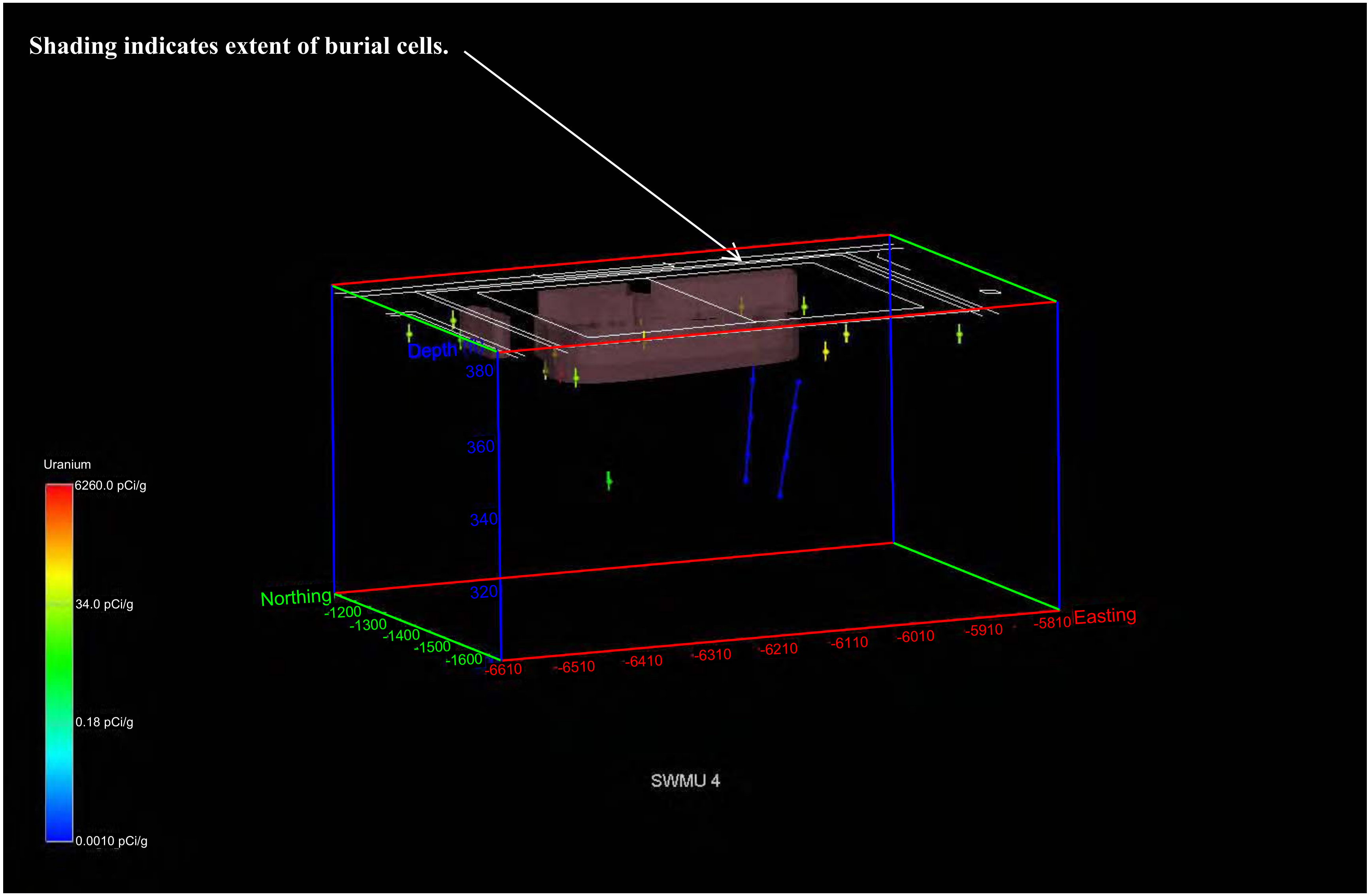

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Figure 5.20. SWMU 4 Total Uranium in Soil

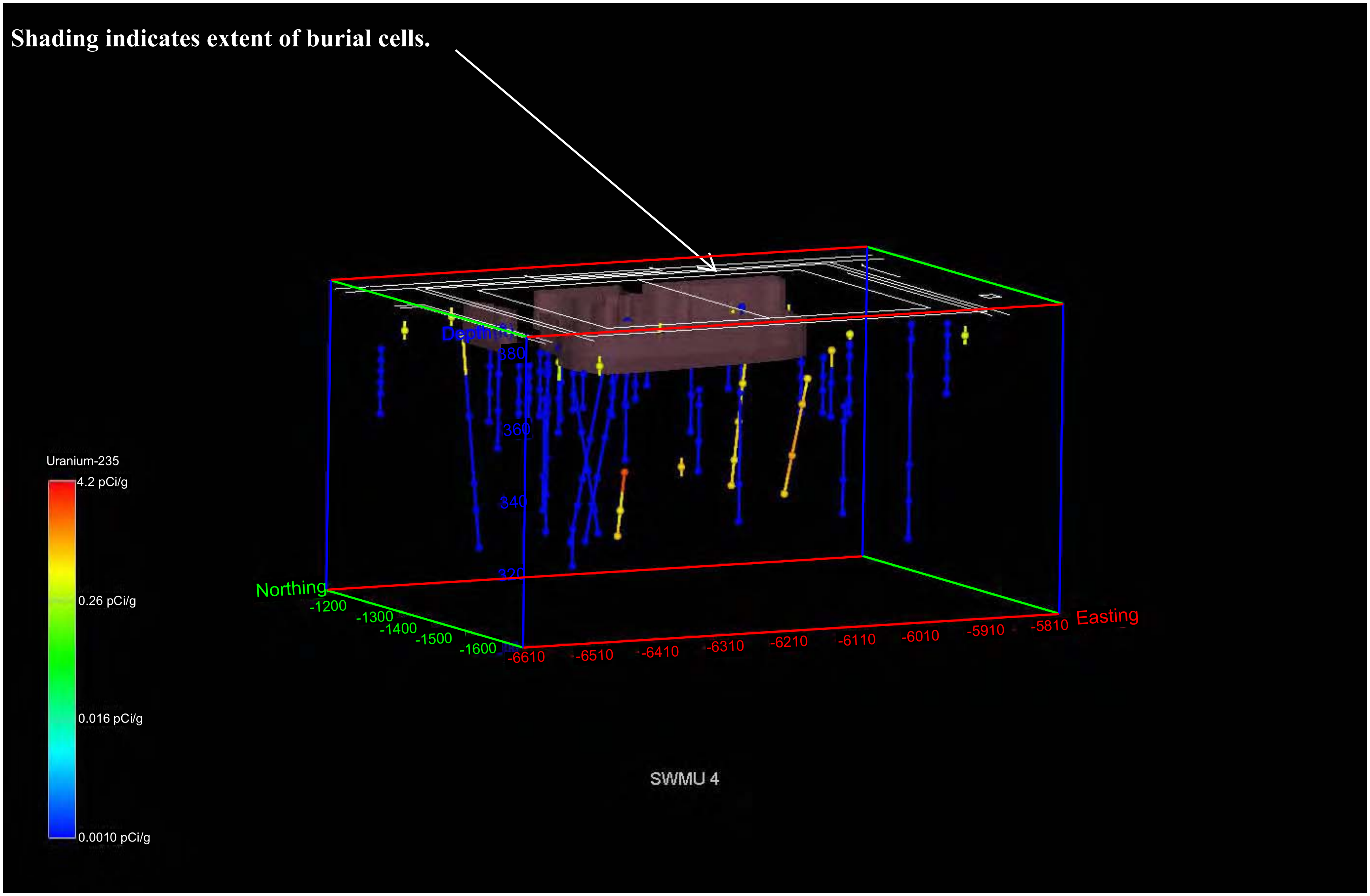

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Figure 5.21. SWMU 4 Uranium-235 in Soil

During the WAG 3 investigation, numerous vertical and angle borings were advanced adjacent to and beneath the burial cells to collect subsurface soil samples. All of these borings terminated in the UCRS, above the RGA. No RGA soil samples were collected during the WAG 3 investigation.

5.2.1.3 SWMUs 5 and 6

Figures 5.22 and 5.23 show the 74 soil sampling data points around SWMUs 5 and 6, respectively, associated with the historical OREIS data set described at the beginning of this chapter. Figures 5.24 through 5.31 show various contamination levels found in soils around SWMUs 5 and 6. The highest detected levels for each of these contaminants are lower than the Industrial Work Risk-Based Action Level.

During investigation activities in the early 1990s at SWMU 5, subsurface soil samples were collected, and an additional groundwater MW was installed. The samples collected during the WAG 3 RI and during the 1991 and 1992 investigations indicate that contamination of surface soil is minimal. During the WAG 3 investigation, numerous vertical and angle borings were advanced adjacent to and beneath the burial cells to collect subsurface soil samples. All of these borings terminated in the UCRS, above the RGA. No RGA soil samples were collected during the WAG 3 investigation.

Waste at SWMU 5 is buried in several burial cells of varying sizes to a depth of approximately 15 ft bgs. Only sporadic and widely spaced contaminants were detected, including some PCBs, polycyclic aromatic hydrocarbons (PAHs), and pesticides and herbicides, in shallow soils. No data within the burial cells were collected, due to the nature of the wastes (DOE 2000c).

Radiological contamination was limited to a few occurrences of ^{99}Tc (ranging from 4.2 to 5.85 pCi/g). There is no evidence that this contamination is widespread, so no estimate of volumes of contaminated areas is offered.

PCBs were found in limited surface and shallow subsurface soils. The concentrations ranged from 35 to 306 µg/kg. There is no evidence that this contamination is widespread, so no estimate of volumes of contaminated areas is offered.

Pesticides, herbicides, and PAHs were found in approximately five surface and shallow subsurface soil samples. Because these samples are above the expected depth at which the wastes were buried, and because the nature of these contaminants is inconsistent with what is known about the buried material (i.e., components from the "Work for Others" activities and metal slag), it is unlikely that these contaminants are associated with the burial cells. No estimate of volumes of contaminated areas is offered.

Potential contaminants associated with SWMU 6 surface and subsurface soils are metals and radionuclides. Contaminants at SWMU 6 are buried in several burial cells of varying size to a depth of approximately 6 ft bgs. Only sporadic and widely spaced contaminants were detected, including some semivolatile organic compounds (SVOCs), metals, and radioisotopes in shallow soils, and some PCBs and radioisotopes in groundwater. Limited data collected within the burial cells indicated the presence of radioisotopes and PCBs.

Radiological contamination was limited to a few occurrences of ^{99}Tc, ^{237}Np, and ^{234}Th (ranging from 0.125 to 8.51 pCi/g). Because there is no evidence that this contamination is widespread, no estimate of volumes of contaminated areas is offered.

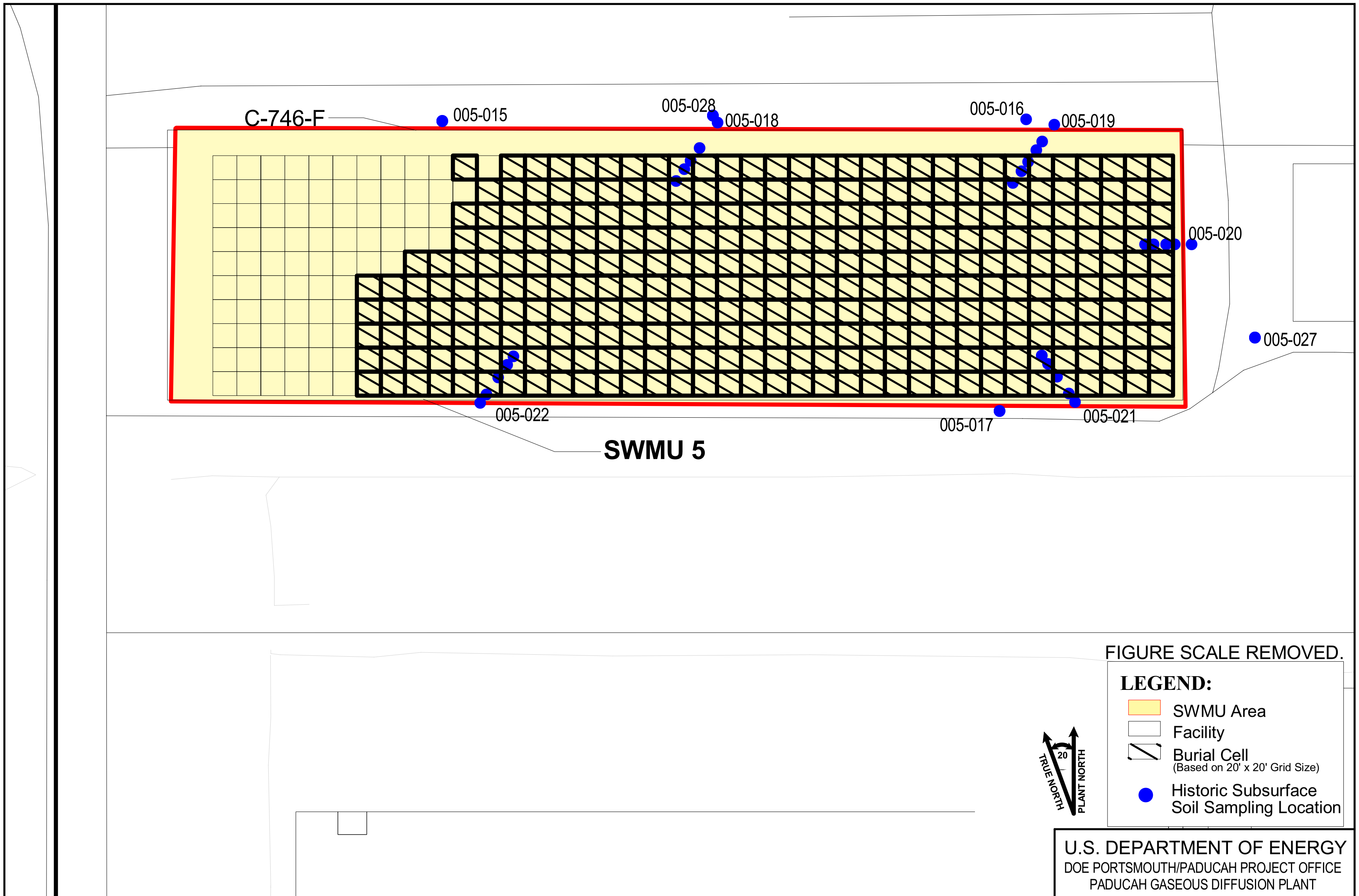

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Figure 5.22. SWMU 5 Historical Subsurface Soil Sampling Locations

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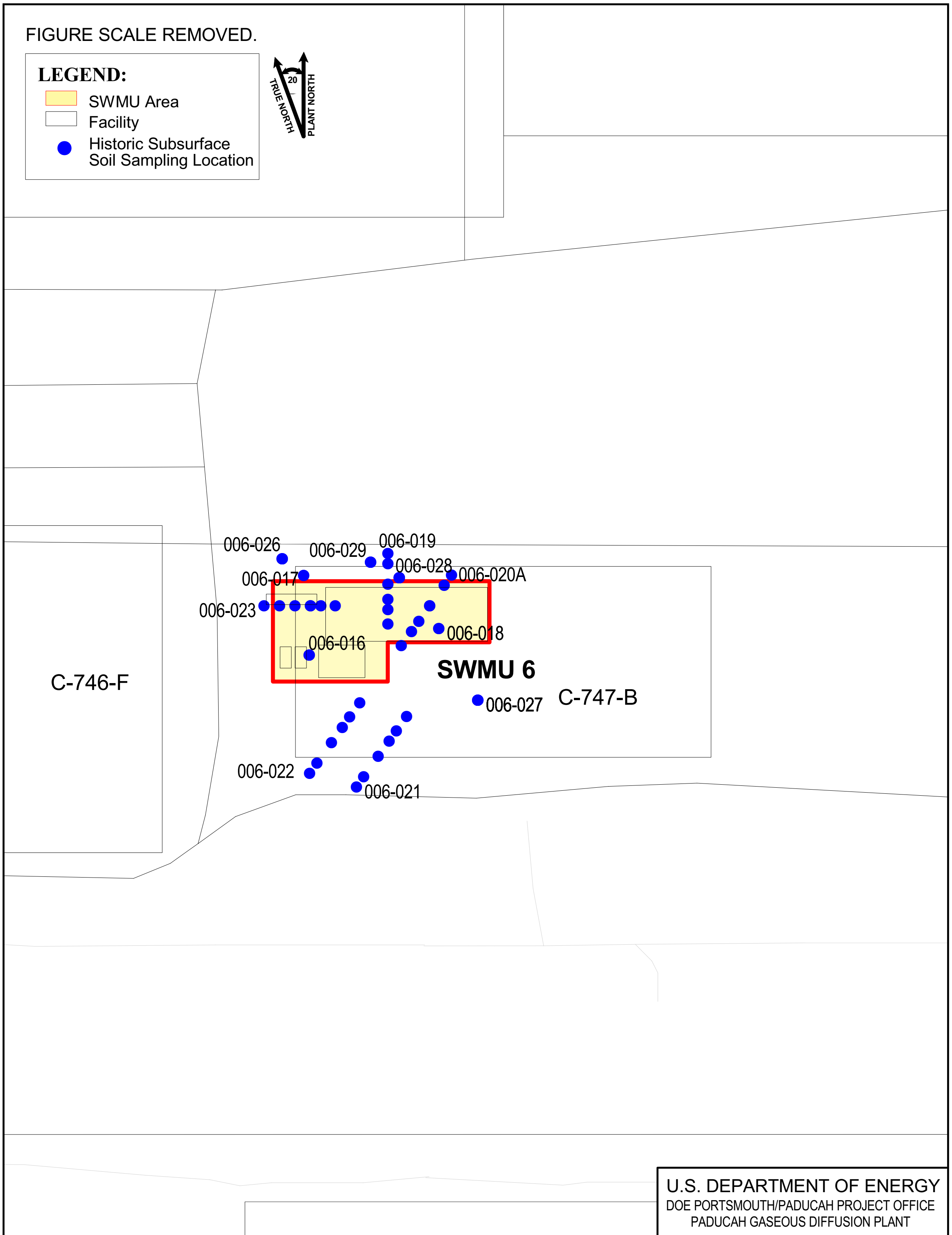

Figure 5.23. SWMU 6 Historical Subsurface Soil Sampling Locations

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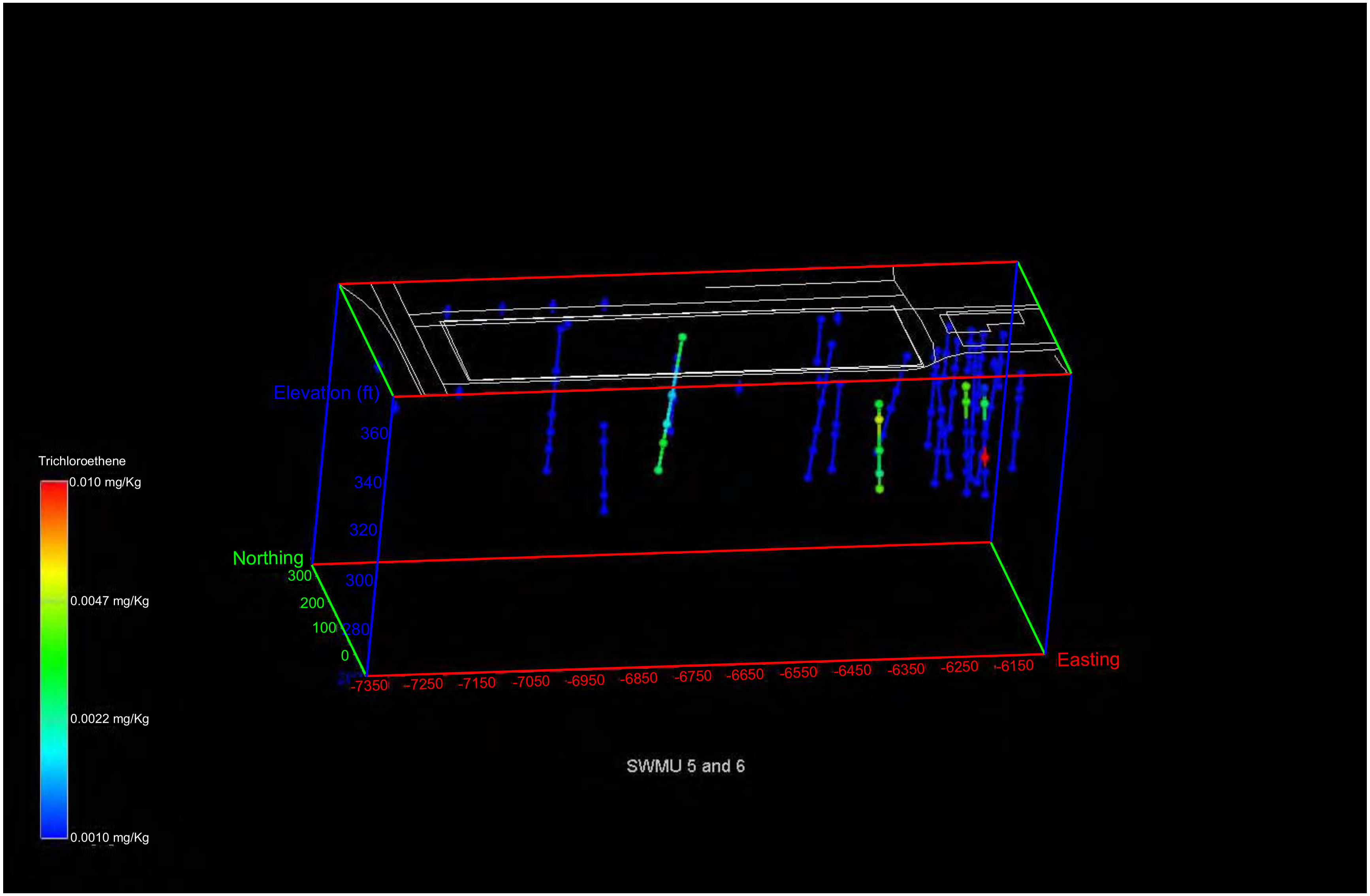

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Figure 5.24. SWMUs 5 and 6 TCE in Soil

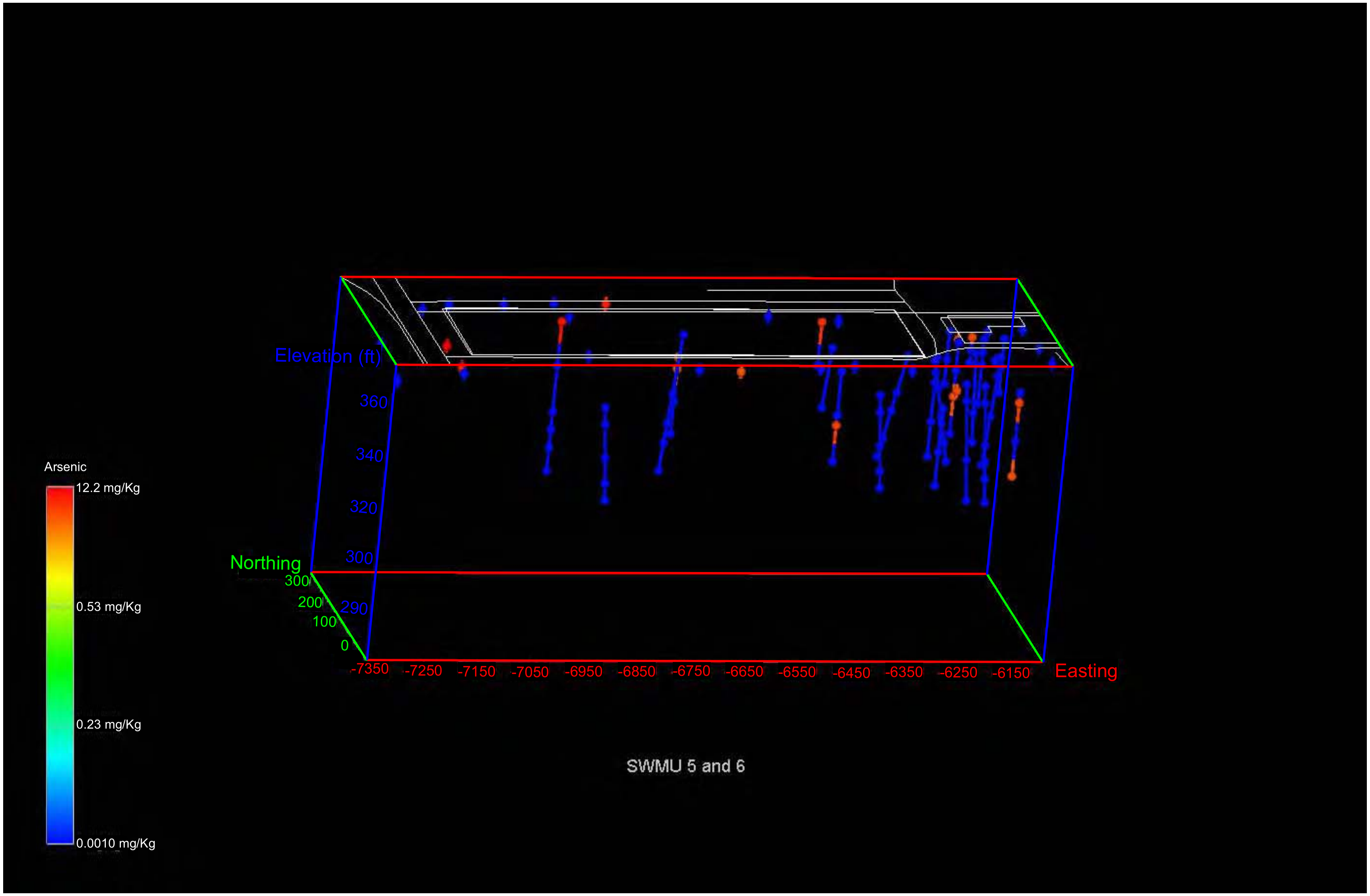

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Figure 5.25. SWMUs 5 and 6 Arsenic in Soil

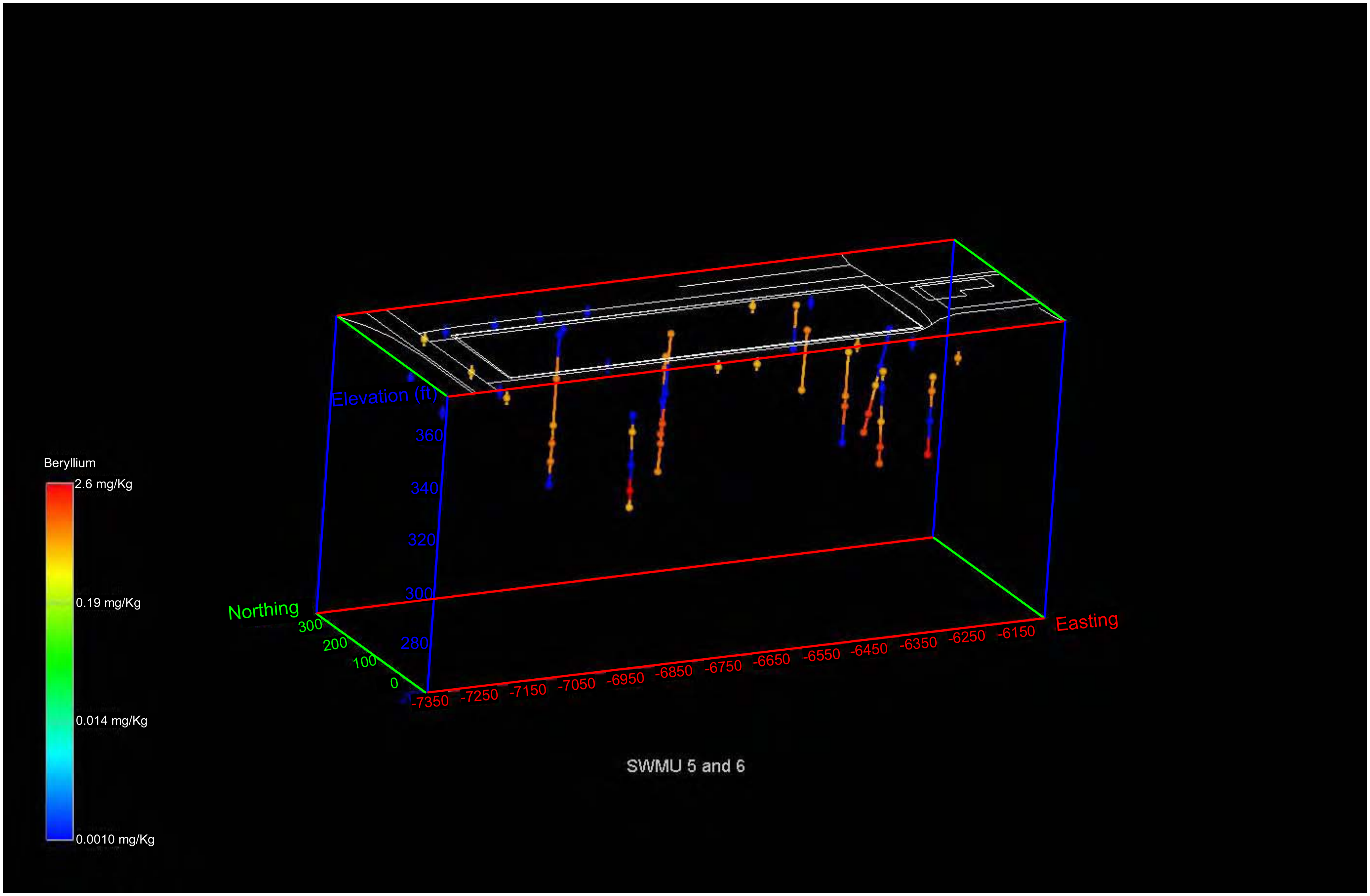

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Figure 5.26. SWMUs 5 and 6 Beryllium in Soil

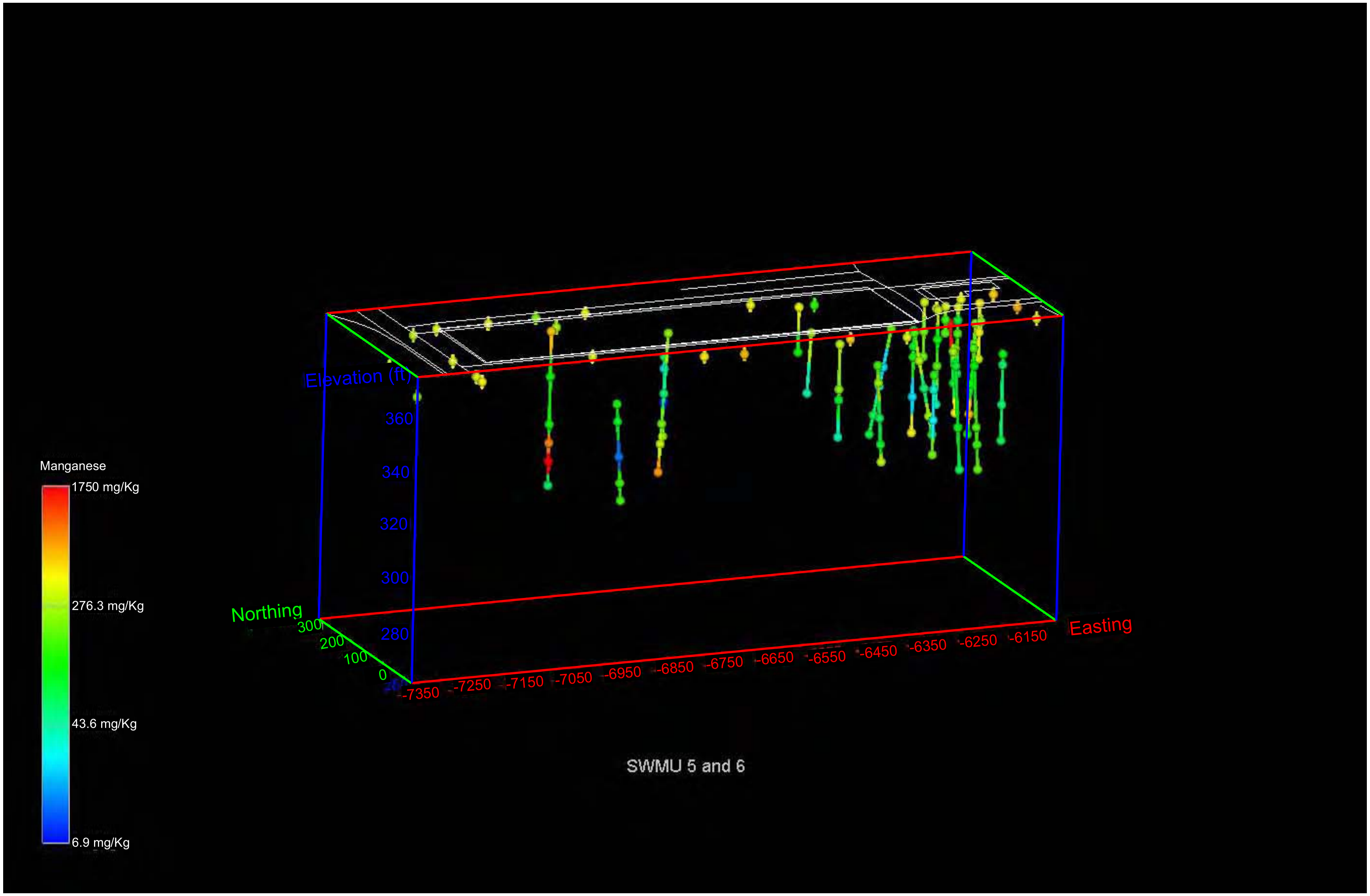

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Figure 5.27. SWMUs 5 and 6 Manganese in Soil

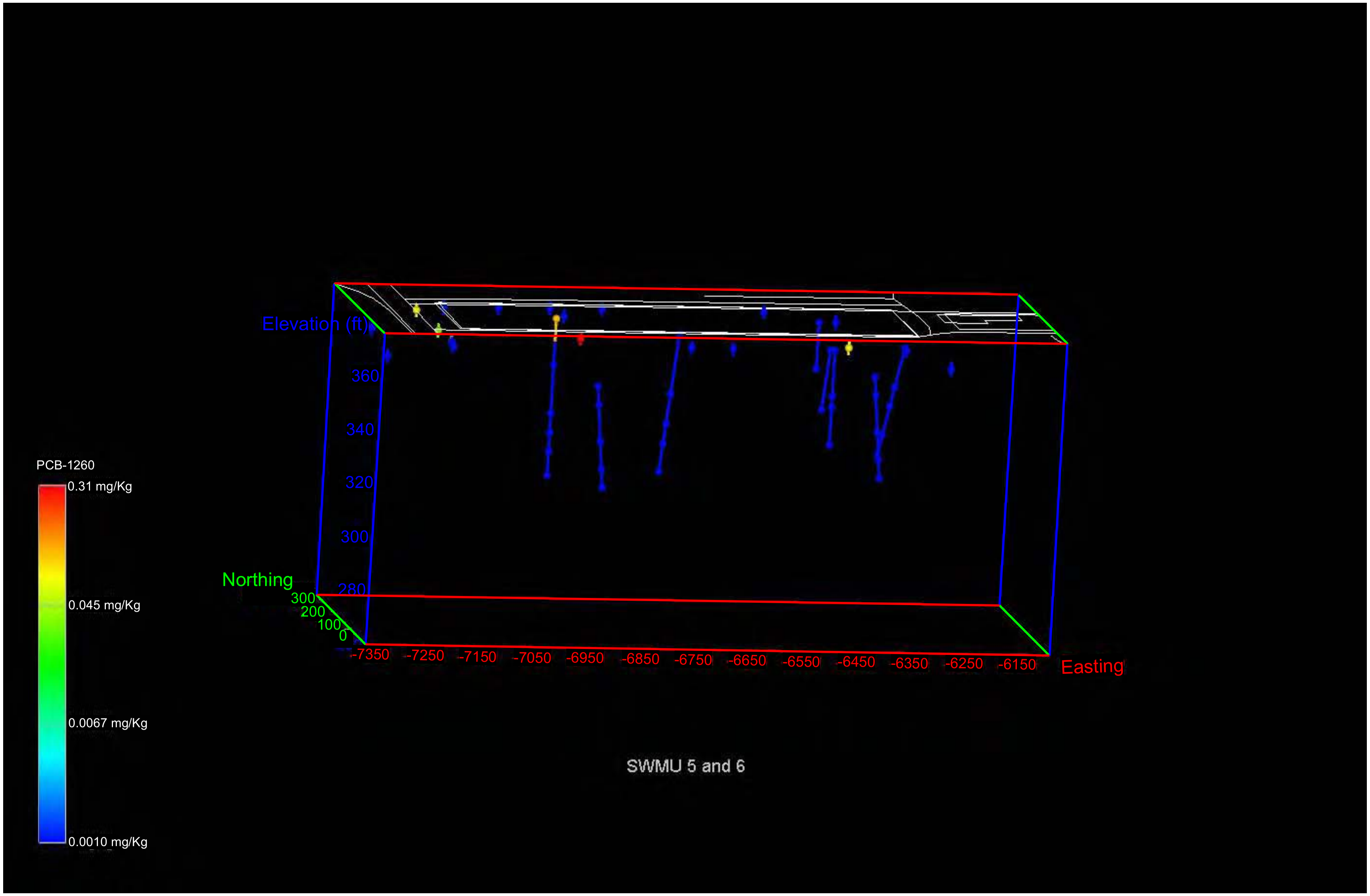

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Figure 5.28. SWMUs 5 and 6 PCB-1260 in Soil

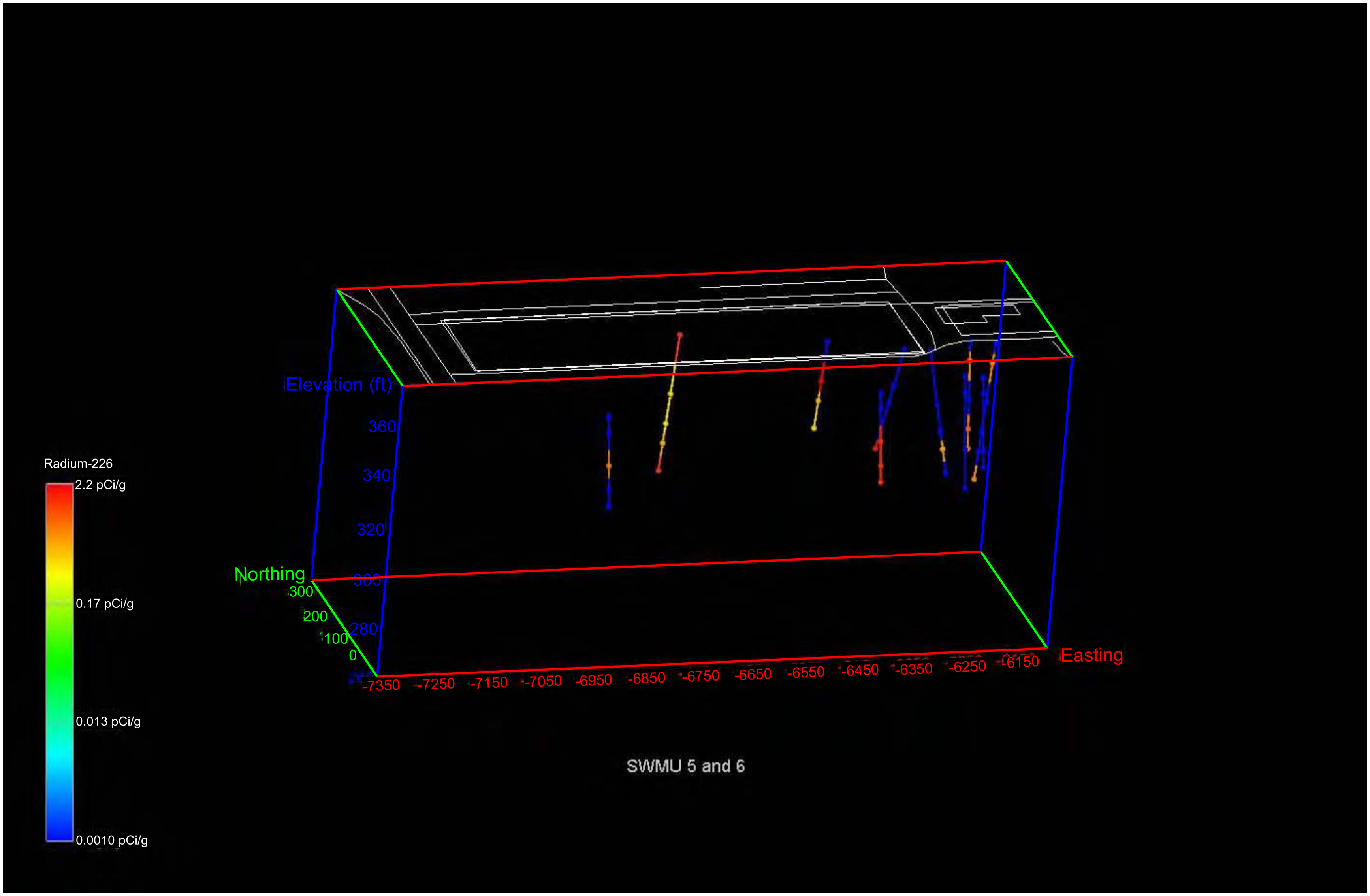

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Figure 5.29. SWMUs 5 and 6 Radium-226 in Soil

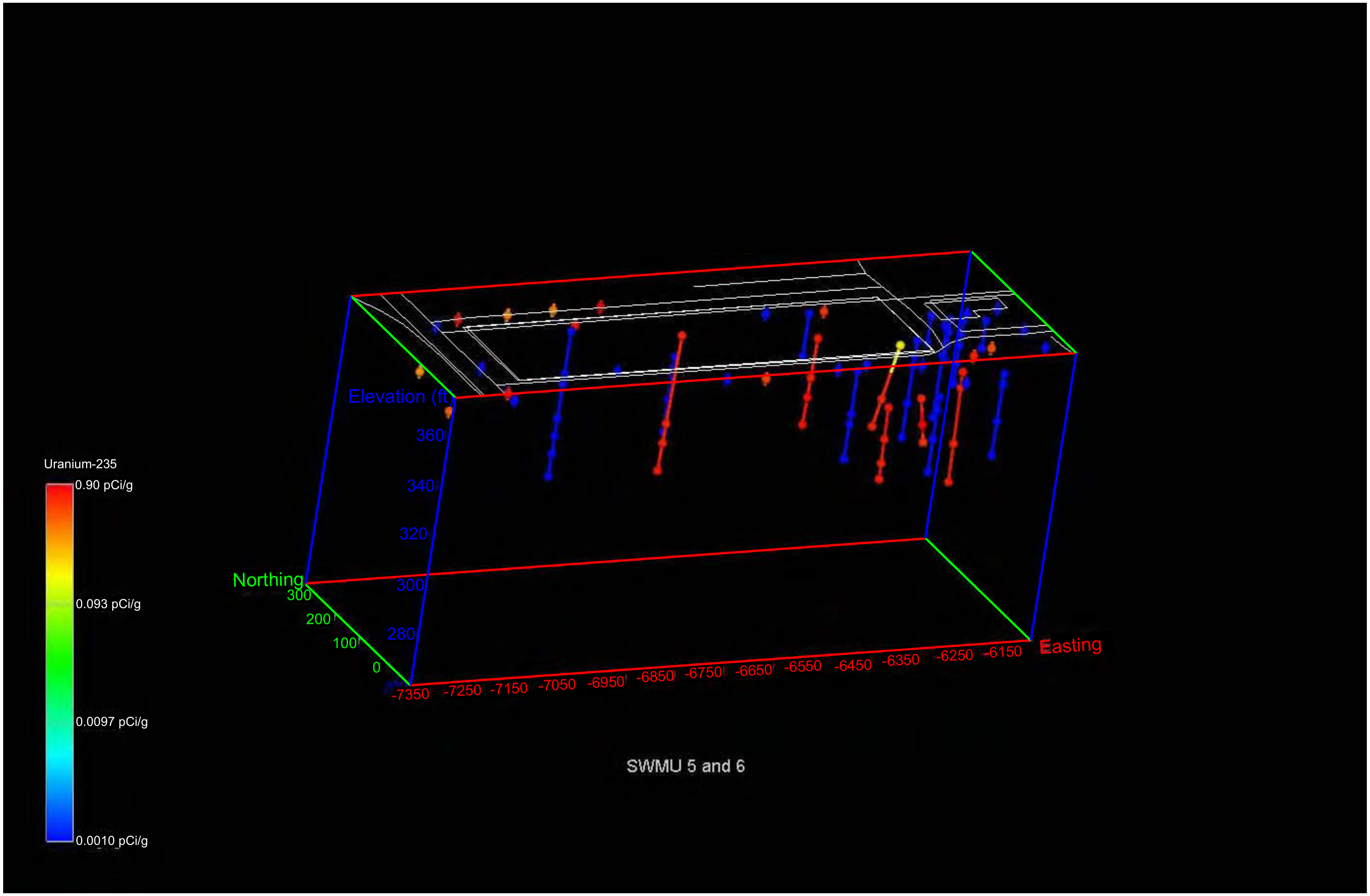

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Figure 5.30. SWMUs 5 and 6 Uranium-235 in Soil

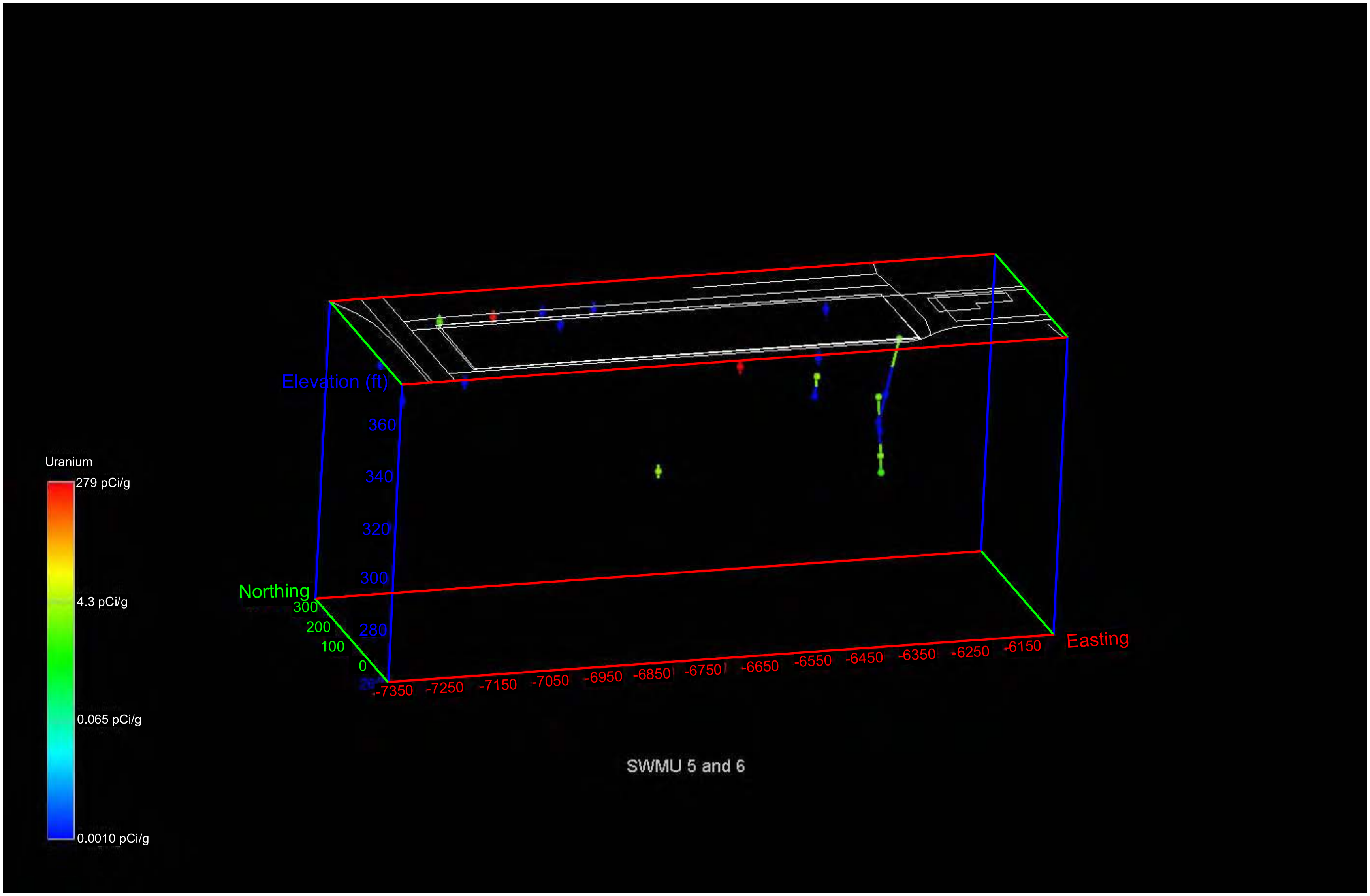

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Figure 5.31. SWMUs 5 and 6 Total Uranium in Soil

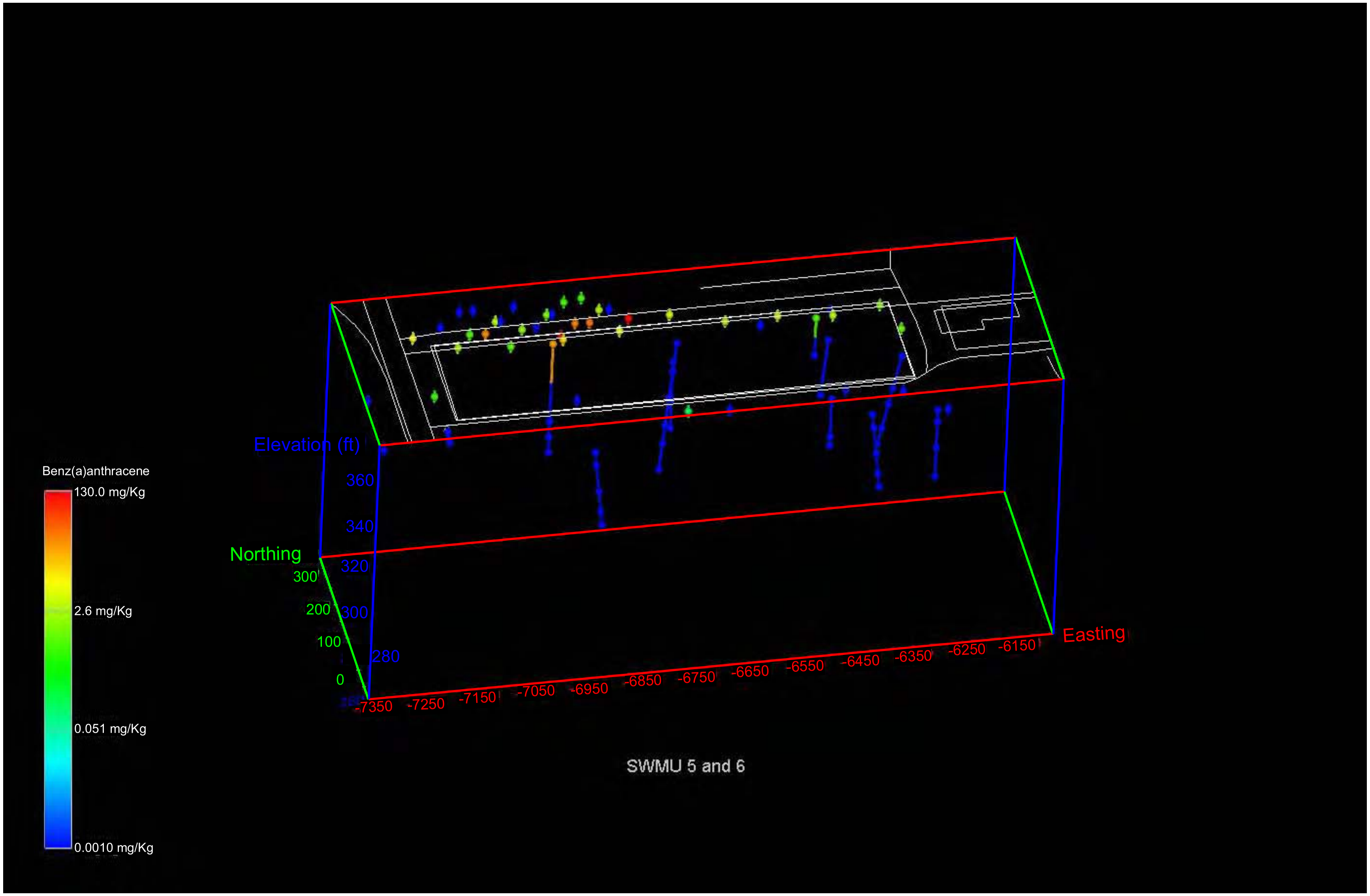

Figure 5.32. SWMUs 5 and 6 Benz(a)anthracene in Soil

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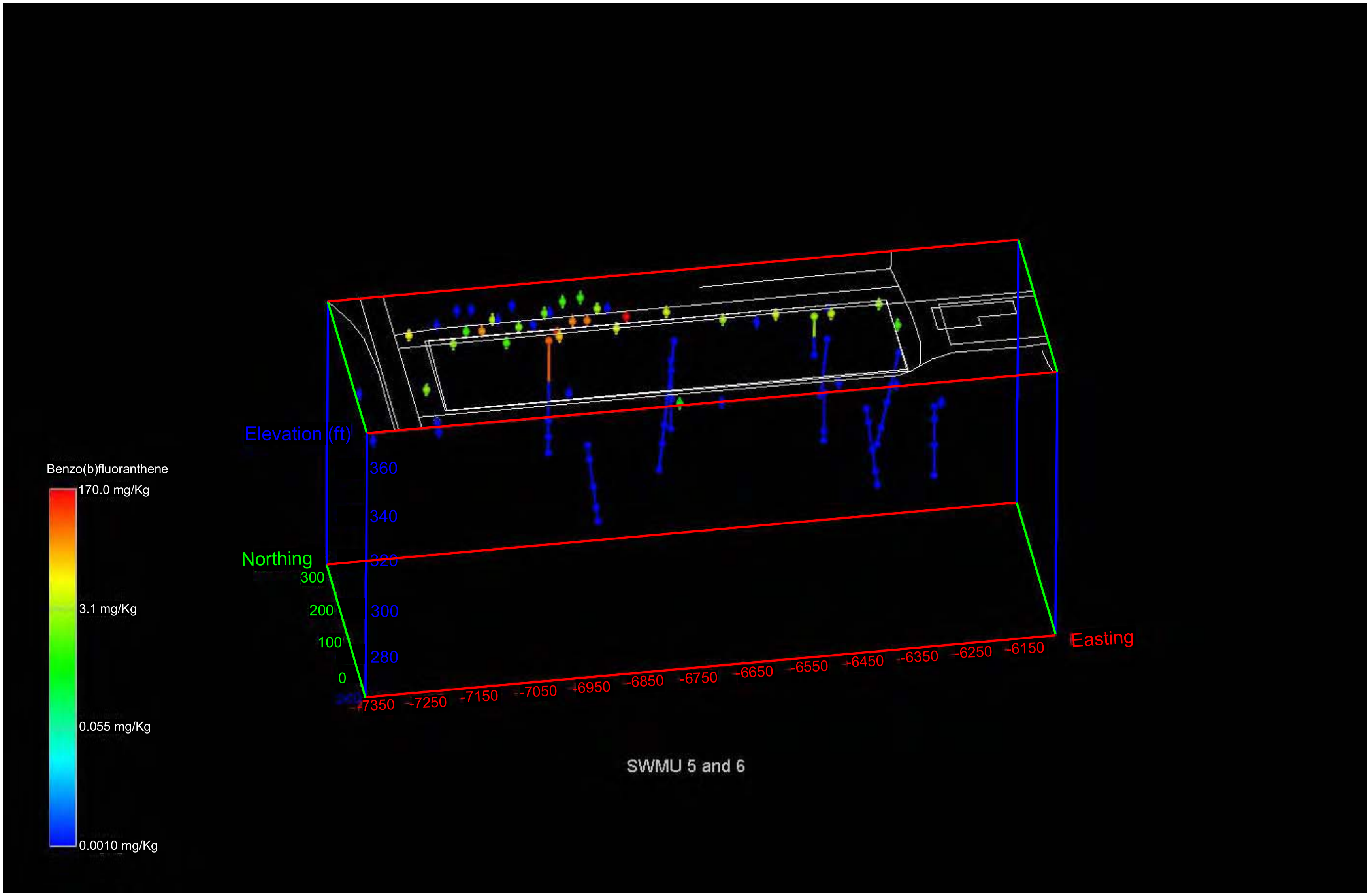

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Figure 5.33. SWMUs 5 and 6 Benzo(b)fluoranthene in Soil

SVOCs were detected in two surface samples in a drainage ditch/swale located east of the SWMU. Because these samples are above the expected depth at which the wastes were buried, and because the nature of these contaminants is inconsistent with what is known about the buried material, it is unlikely that these contaminants are associated with the burial cells. No estimate of volumes of contaminated areas is offered.

Associated chemical and physical properties of the source areas consist of various industrial wastes and soil backfill in the burial cells, and sands, silts, and clays of the UCRS in the remainder of the SWMU (BJC 2001).

5.2.1.4 SWMUs 7 and 30

Figure 5.34 shows the 45 soil sampling data points around SWMUs 7 and 30 associated with the historical OREIS data set described at the beginning of this chapter. Figures 5.35 through 5.46 show various contamination levels found in soils around SWMUs 7 and 30. The highest detected levels for each of these contaminants are lower than the Industrial Work Risk-Based Action Level.

The primary contaminant of surface soils within SWMU 7 is uranium. Total elemental uranium in surface soils ranges as high as 1400 mg/kg near the northeast corner of the SWMU. In general, uranium activity in surface soils is highest on the eastern edge of SWMU 7 and in a north/south-oriented band in the western half of the SWMU. The level of contamination of surface soils beneath Drum Mountain has not been measured. A radiation walkover survey of SWMU 7, from the Phase II SI, revealed that radiological surface contamination exceeded the background gamma radiation level of a nearby reference site, over approximately two-thirds of the SWMU, by a factor of 3 (DOE 1998d).

Beryllium, chromium, copper, nickel, and zinc metals frequently are detected at concentrations slightly above background in surface soils across SWMU 7. Likewise, PAHs are detected at low concentrations in surface soils. PCB concentrations typically are below 0.1 parts per million (ppm), but increase to as much as 1.8 ppm on the west side of SWMU 7 (sample 55-01). PAHs range between 0 and 24 ppm in the SWMU.

Soil erosion from SWMU 7 appears to be contributing elevated concentrations of copper, nickel, and zinc to the south drainage ditch, and uranium and low levels of metals contamination to sediments and surface water in the north drainage ditch. Scrap yards to the east of SWMU 7 are upgradient sources of the same contaminants to the north ditch. Upgradient sources account for a high uranium activity in the south ditch.

Subsurface soils, outside of Burial Pits B and C, do not appear to be contaminated. In Burial Pits B and C, soils contain high activities of uranium and concentrations of cadmium, chromium, copper, nickel, and zinc above background levels. Soil samples from Burial Pits D and F have little to no contamination.

Surface soil contamination by PCBs and PAHs extends from the site of the former incinerator to the south drainage ditch. All PCB detections, except one, are less than 4 ppm. The highest sample result was 15 ppm of Aroclor-1260 (the carcinogenic PCB). The highest sample result for PAHs concentration is 48 ppm. Uranium activity of the surface soil is generally less in SWMU 30 than was observed at SWMU 7. The radiation walkover survey of SWMU 30, conducted during the Phase II SI, identified only isolated areas where surface radiological contamination exceeded three times background activity as measured at nearby reference sites (DOE 1998d).

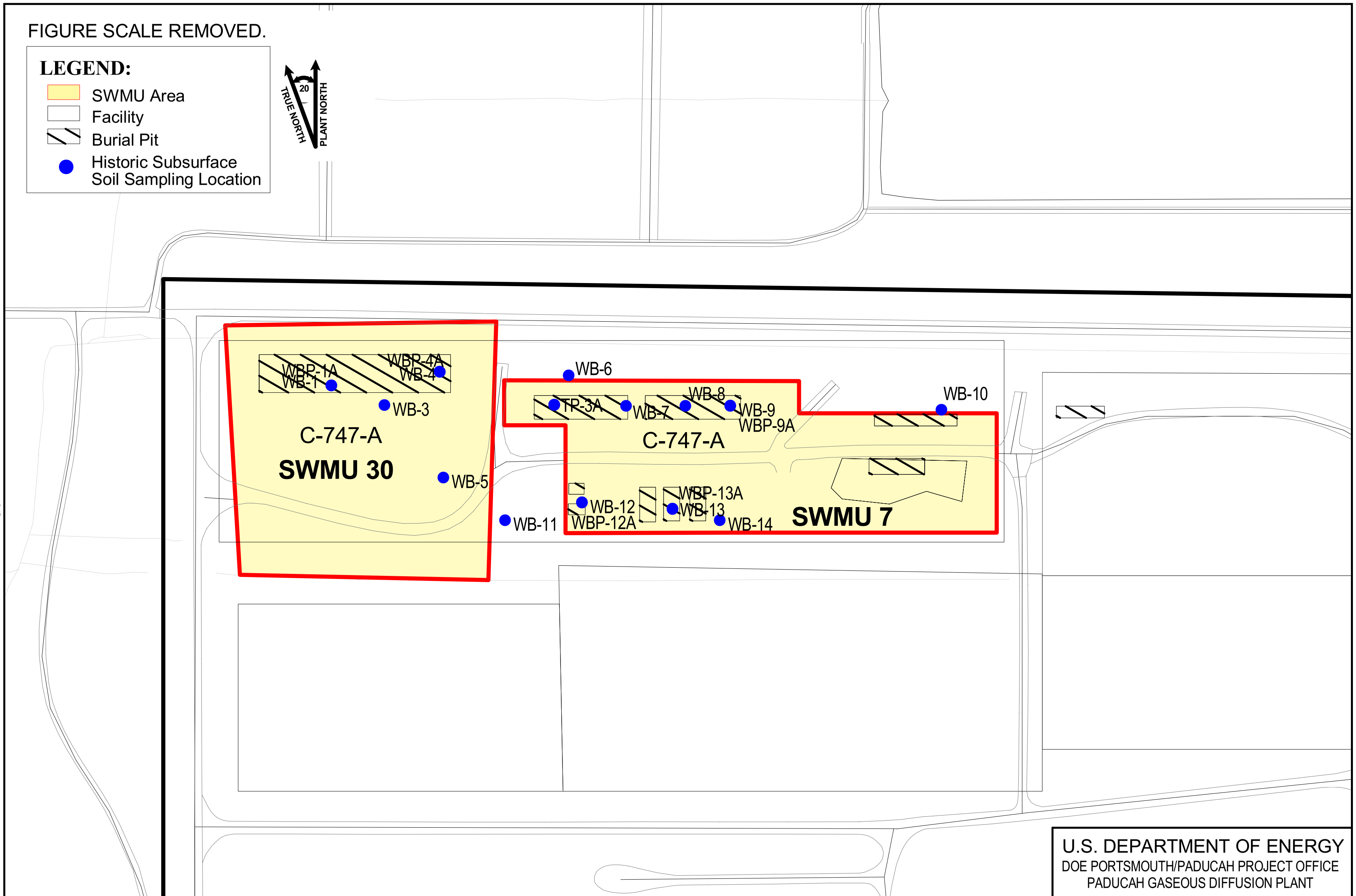

Figure 5.34. SWMUs 7 and 30 Historical Subsurface Soil Sampling Locations

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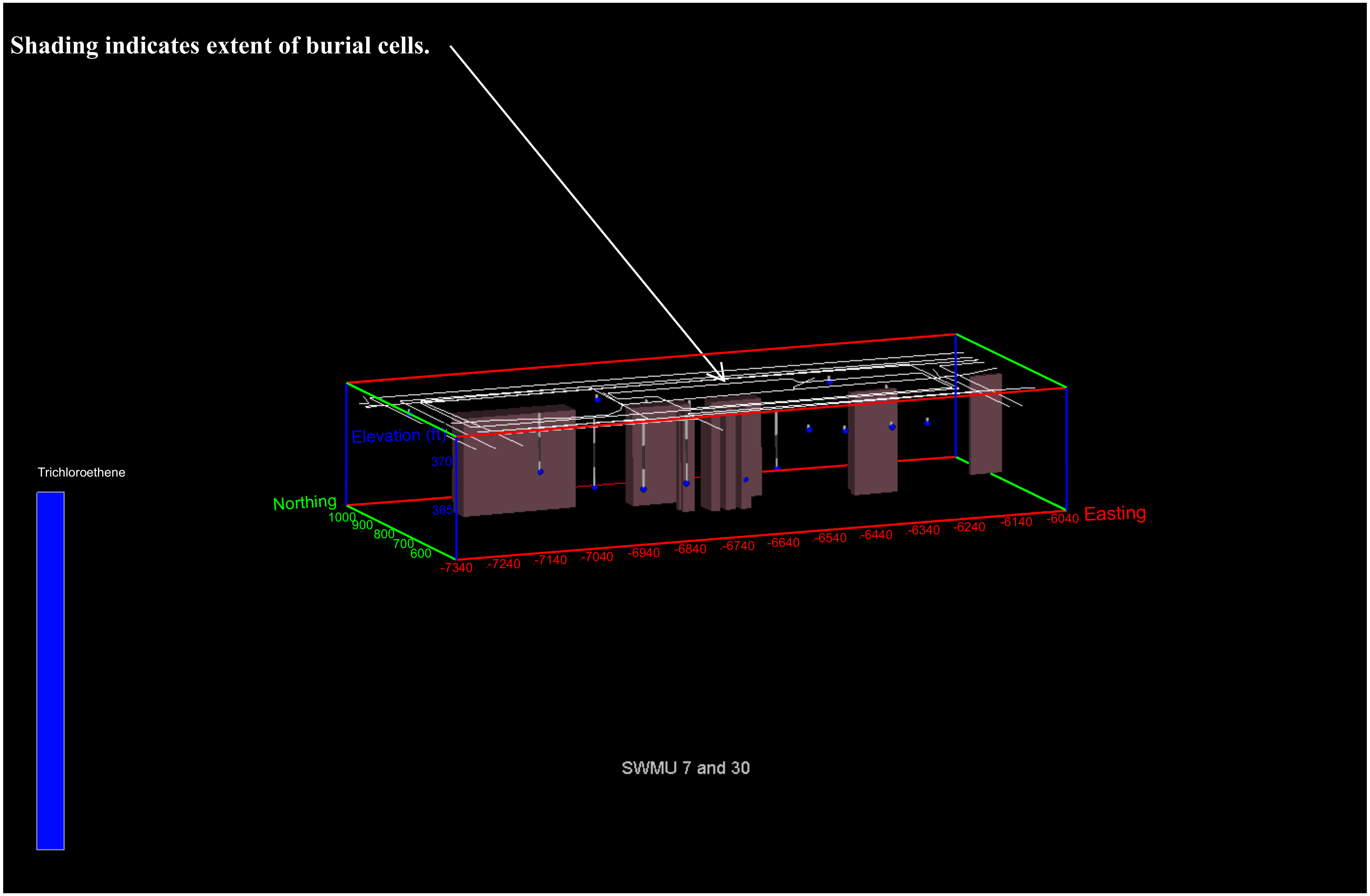

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Figure 5.35. SWMUs 7 and 30 TCE in Soil

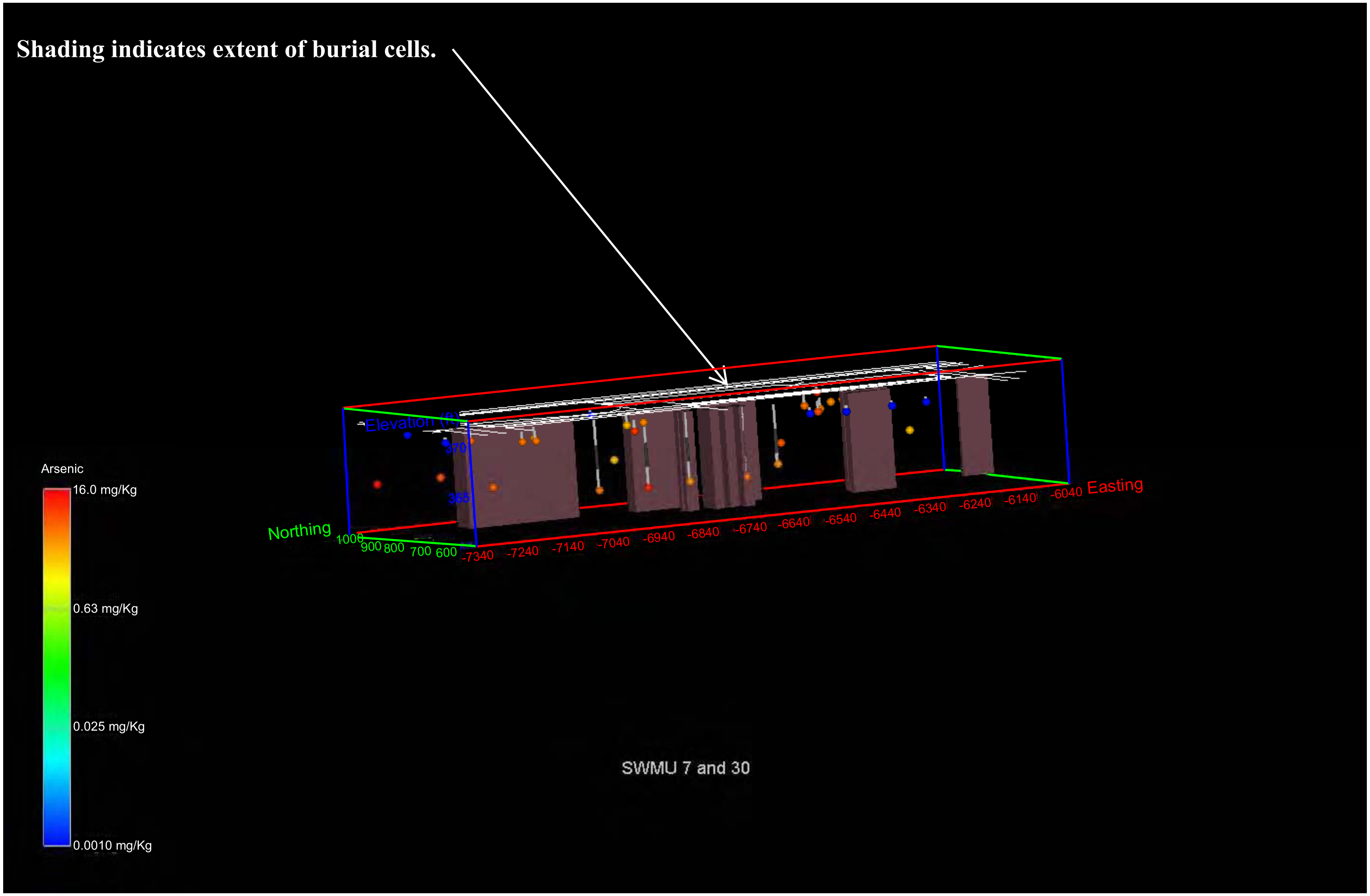

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Figure 5.36. SWMUs 7 and 30 Arsenic in Soil

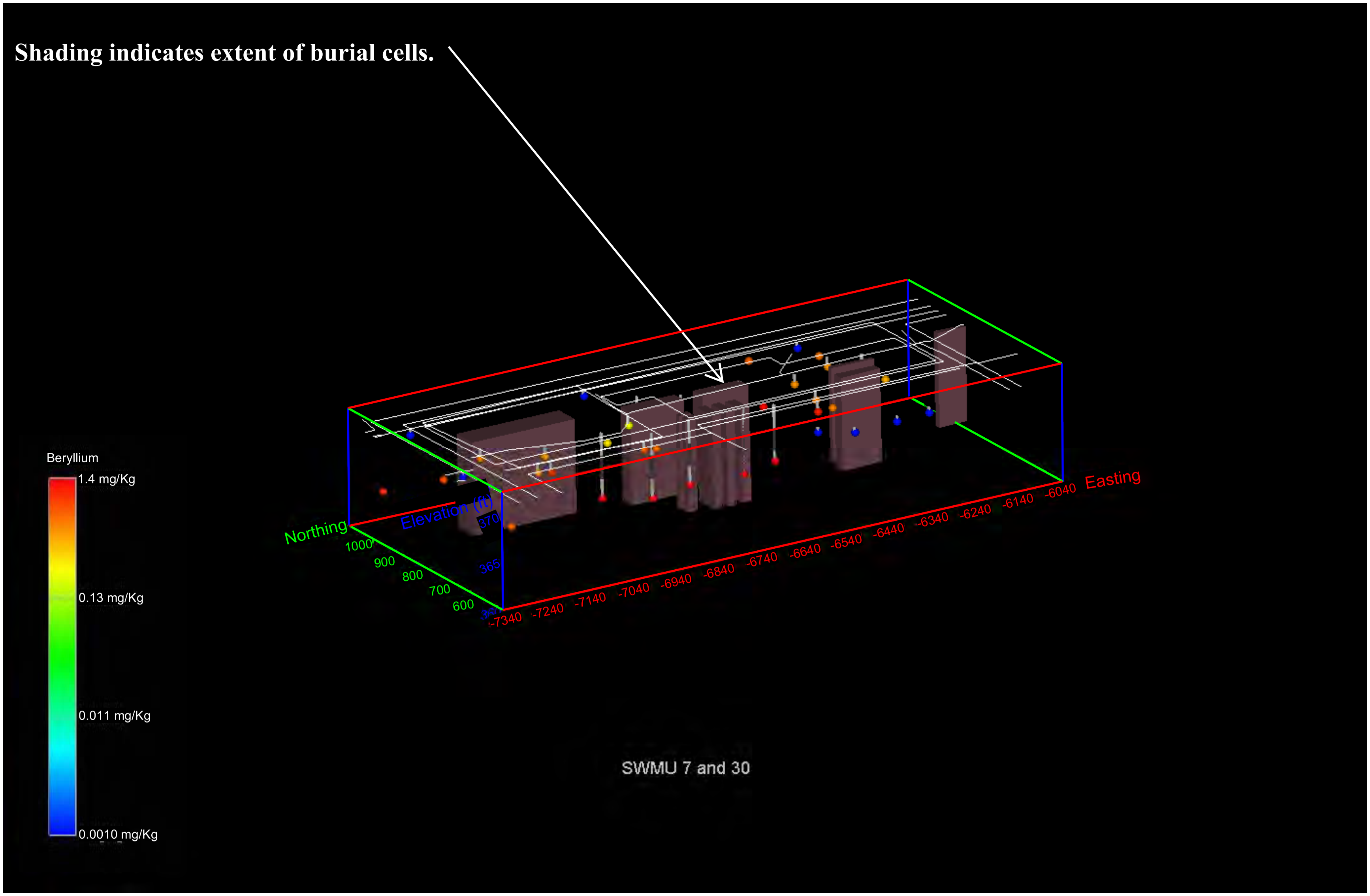

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Figure 5.37. SWMUs 7 and 30 Beryllium in Soil

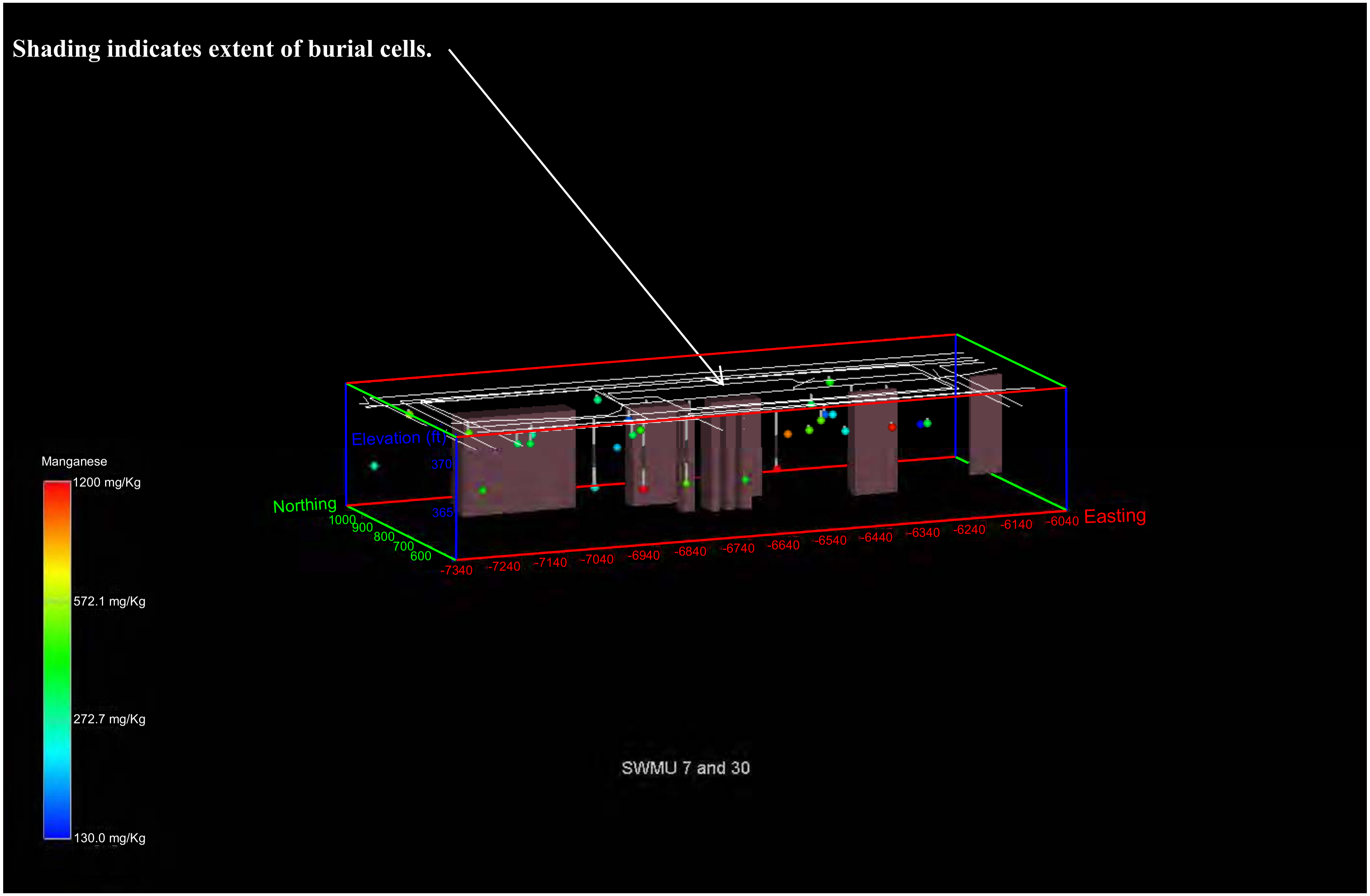

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Figure 5.38. SWMUs 7 and 30 Manganese in Soil

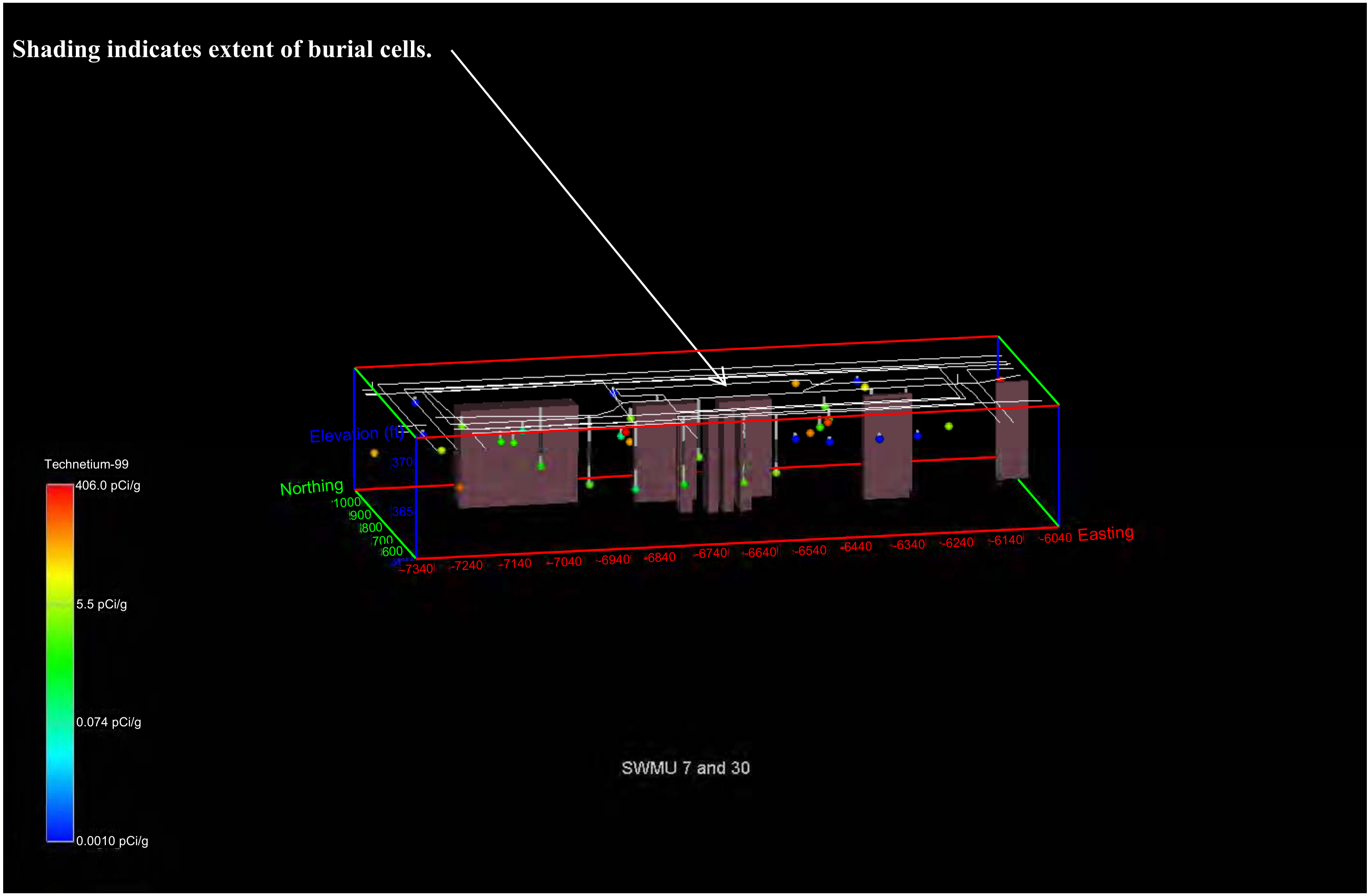

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Figure 5.39. SWMUs 7 and 30 Technetium-99 in Soil

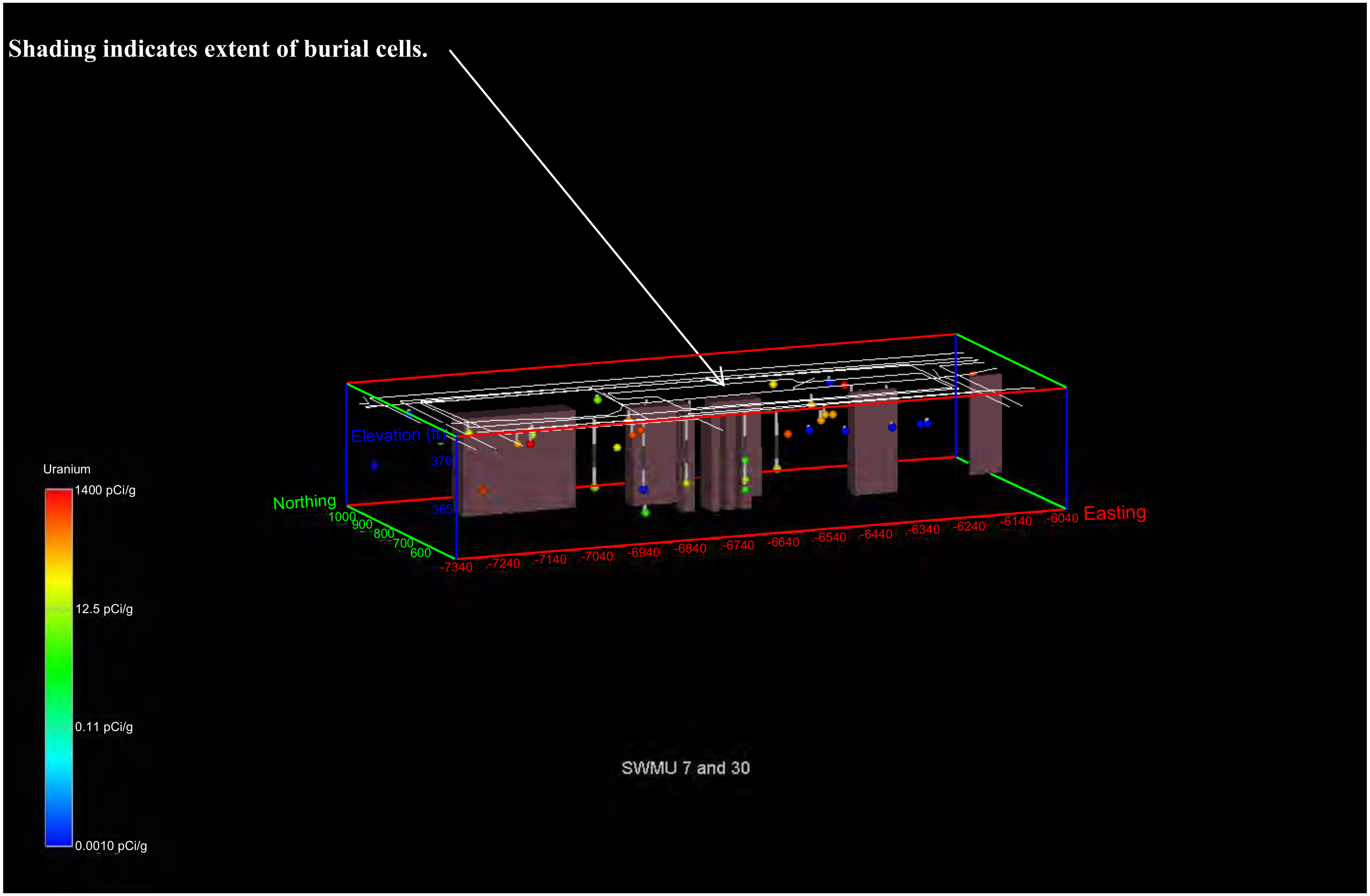

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Figure 5.40. SWMUs 7 and 30 Total Uranium in Soil

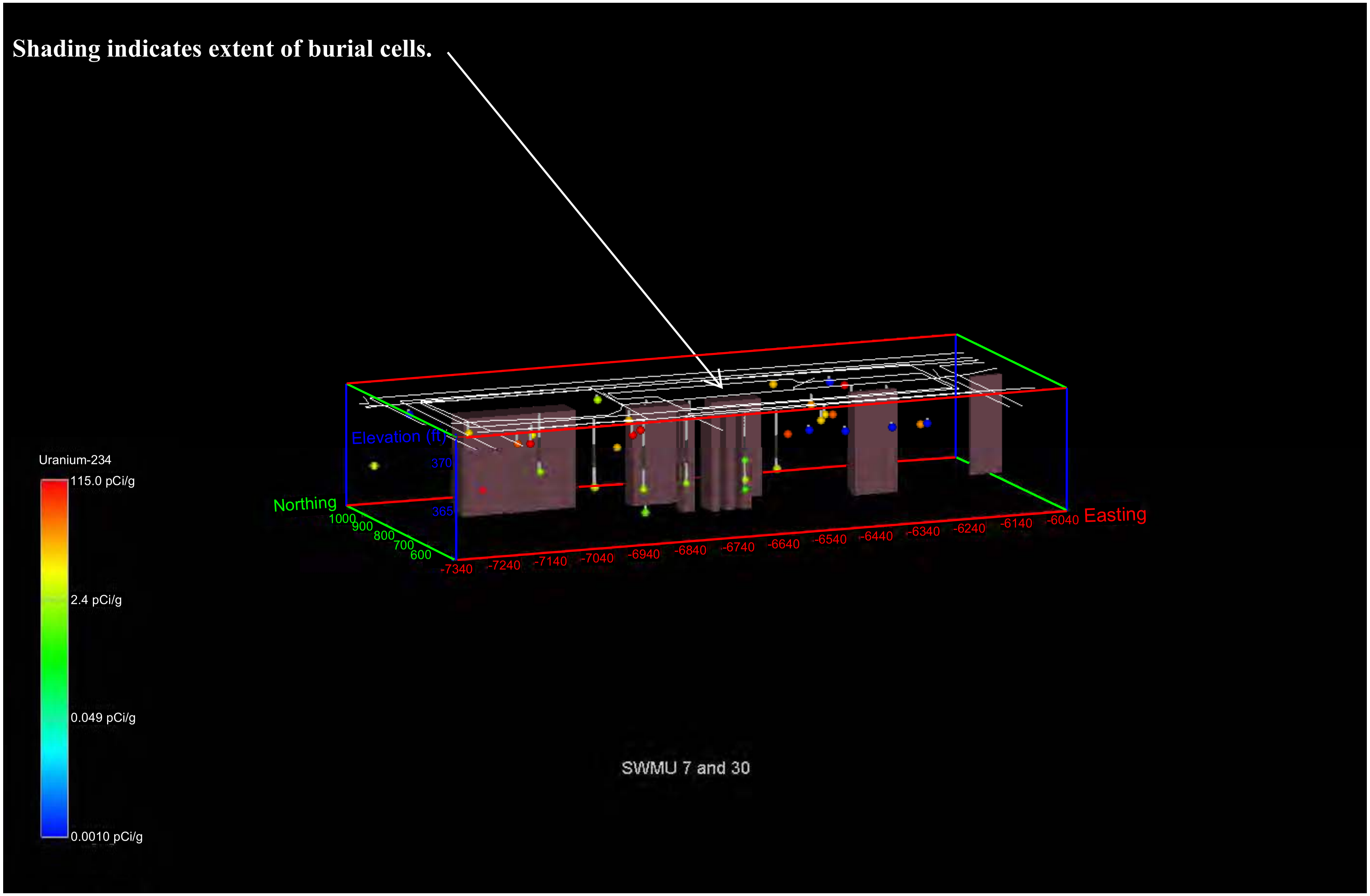

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Figure 5.41. SWMUs 7 and 30 Uranium-234 in Soil

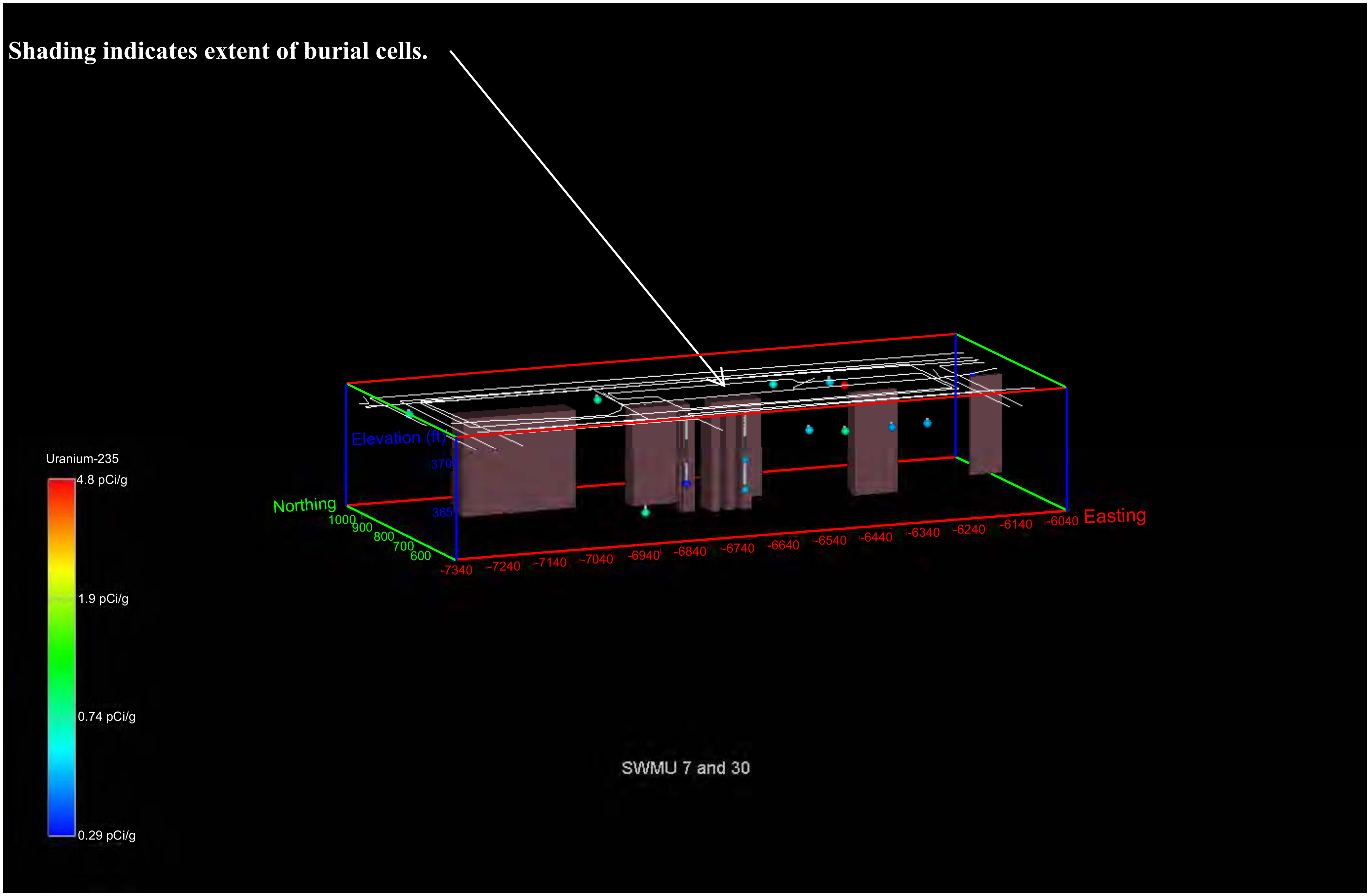

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Figure 5.42. SWMUs 7 and 30 Uranium-235 in Soil

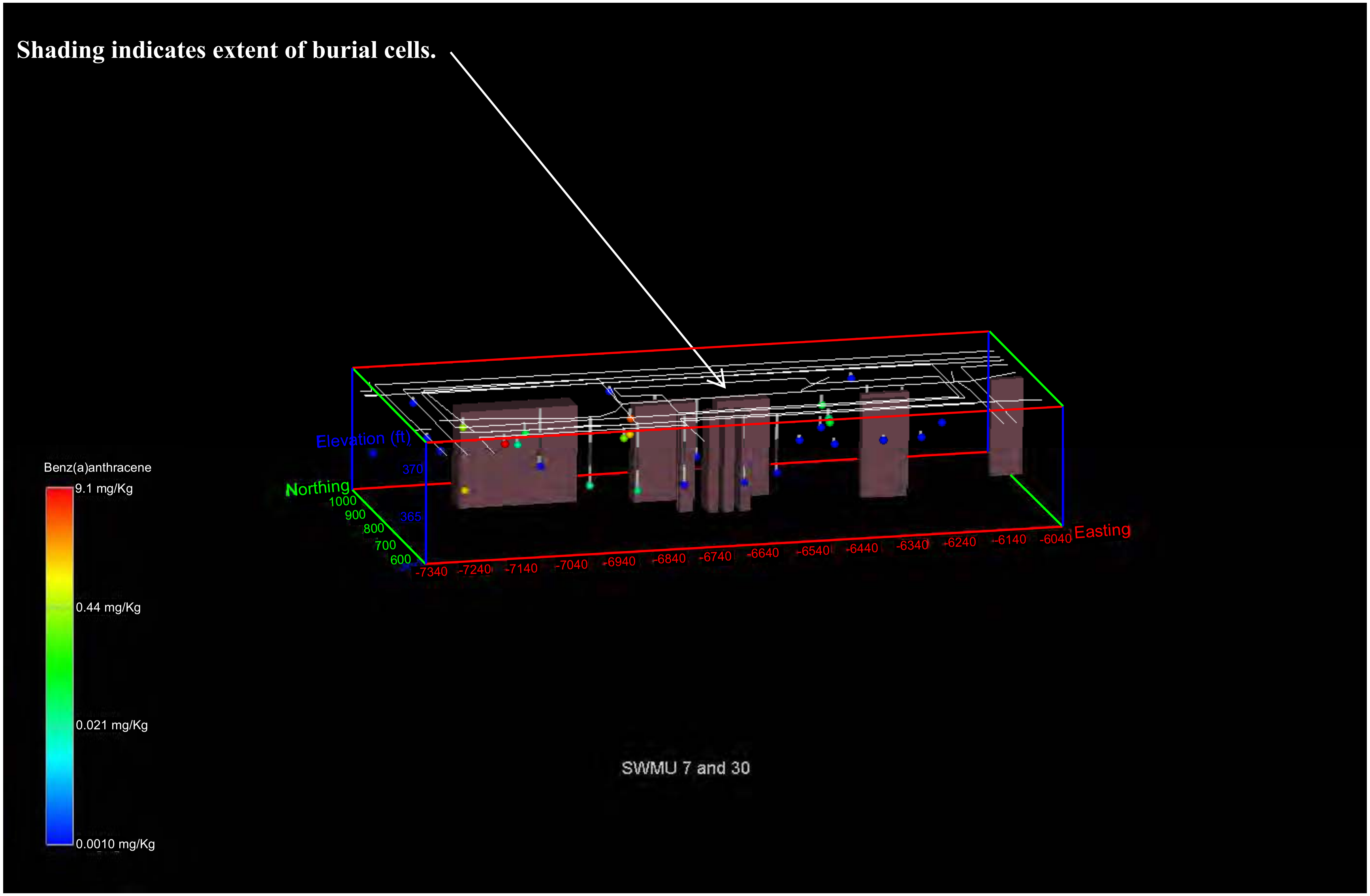

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Figure 5.43. SWMUs 7 and 30 Benz(a)anthracene in Soil

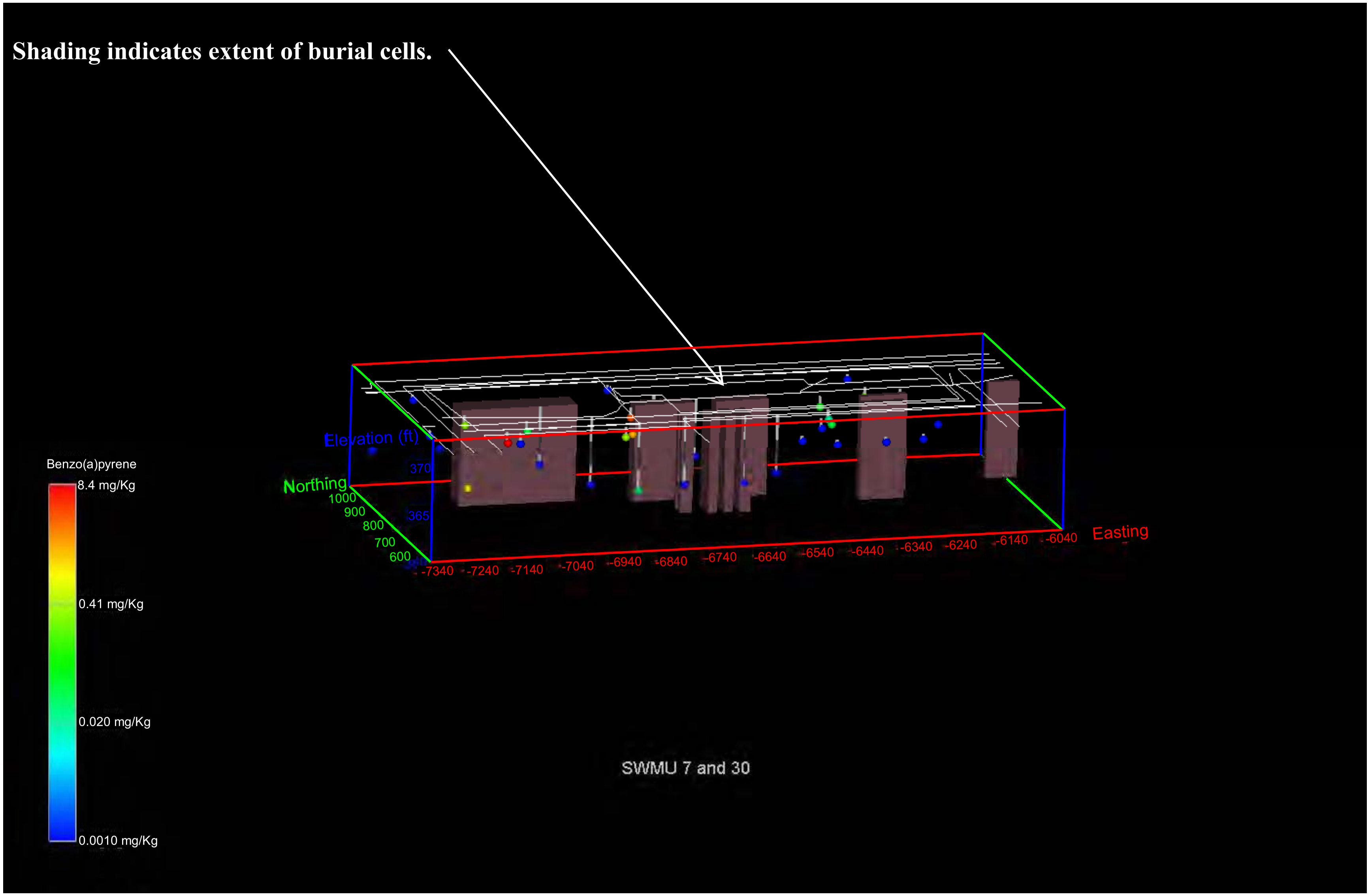

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Figure 5.44. SWMUs 7 and 30 Benzo(a)pyrene in Soil

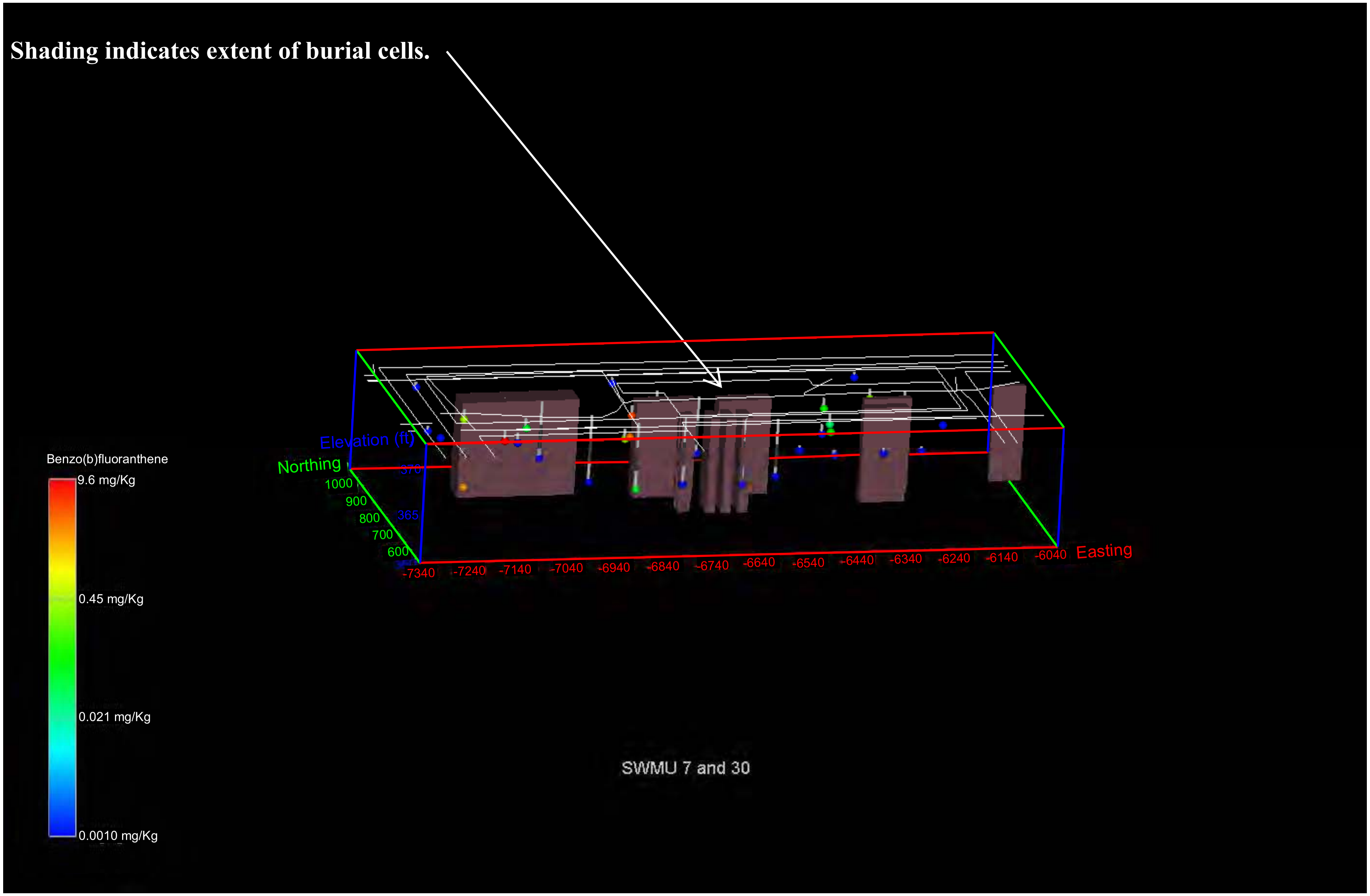

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Figure 5.45. SWMUs 7 and 30 Benzo(b)fluoranthene in Soil

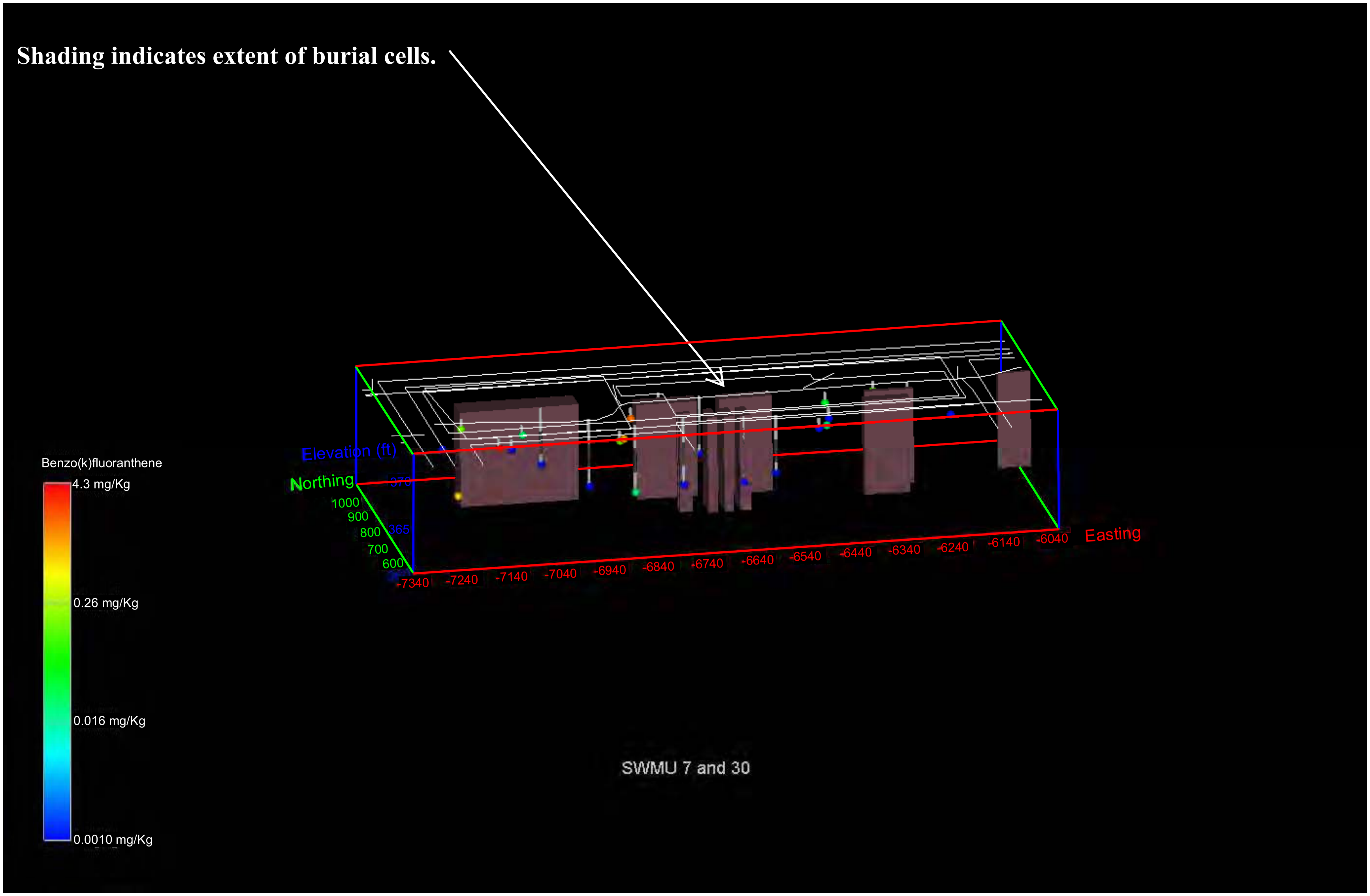

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Figure 5.46. SWMUs 7 and 30 Benzo(k)fluoranthene in Soil

An FS for SWMUs 7 and 30 was completed in November 1998 (DOE 1998d). Although the FS concluded that SWMU 30 is contributing PCBs to sediments and surface water in the south ditch, elevated levels of metals and uranium occurring in both the north and south drainage ditches appear to be derived from upgradient sources.

Subsurface soils are contaminated with metals and radionuclides at the former incinerator site. Soil samples from Burial Pit A contain elevated levels of metals, radionuclides, and PAHs.

5.2.1.5 SWMU 145

Figure 5.47 shows the 18 soil sampling data points around SWMU 145 associated with the historical OREIS data set described at the beginning of this chapter. Figures 5.48 through 5.53 show various contamination levels found in soils around SWMU 145. The highest detected levels for each of these contaminants are lower than the Industrial Work Risk-Based Action Level.

In 2000, the Department of Justice completed an investigation of a portion of SWMU 145. Five trenches were dug in areas where geophysical surveys identified anomalies. Materials found during trenching activities were roofing materials, construction debris (wood fragments, metal flashing, plastic fragments, etc.), and fly ash. Some of this material was found to be contaminated (DOE 2001a).

5.2.2 Groundwater

5.2.2.1 SWMUs 2, 3, and 4

Figure 5.54 shows the groundwater sampling data points around SWMUs 2, 3, and 4 associated with the June–July 2004 groundwater sampling described at the beginning of this chapter. Figures 5.55 and 5.56 show TCE and ^{99}Tc contamination levels found in groundwater around these SWMUs. Only TCE and ^{99}Tc modeling is provided as these are typical contaminants of concern for PGDP SWMUs. Appendix E provides data for all parameters that have been identified in groundwater in SWMUs 2, 3, and 4.

In 2004, an investigation was completed in accordance with the *Site Investigation Work Plan for the Southwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2003b). The problem statement for this unit reads as follows:

> Hazardous substances, including VOCs and radionuclides, have been detected above maximum contaminant limits in the subsurface soils and groundwater within and immediately adjacent to the boundaries of SWMU 004. It is unknown if or how much contamination is entering the RGA from this unit.

The principal study questions for this unit are as follows:

1. What are the VOCs and their concentrations in the RGA upgradient (east) of SWMU 4?

2. What are the VOCs and their concentrations in the RGA downgradient (west) of SWMU 4?

3. What are the ^{99}Tc activities in the RGA upgradient (east) of SWMU 4?

4. What are the ^{99}Tc activities in the RGA downgradient (west) of SWMU 4?

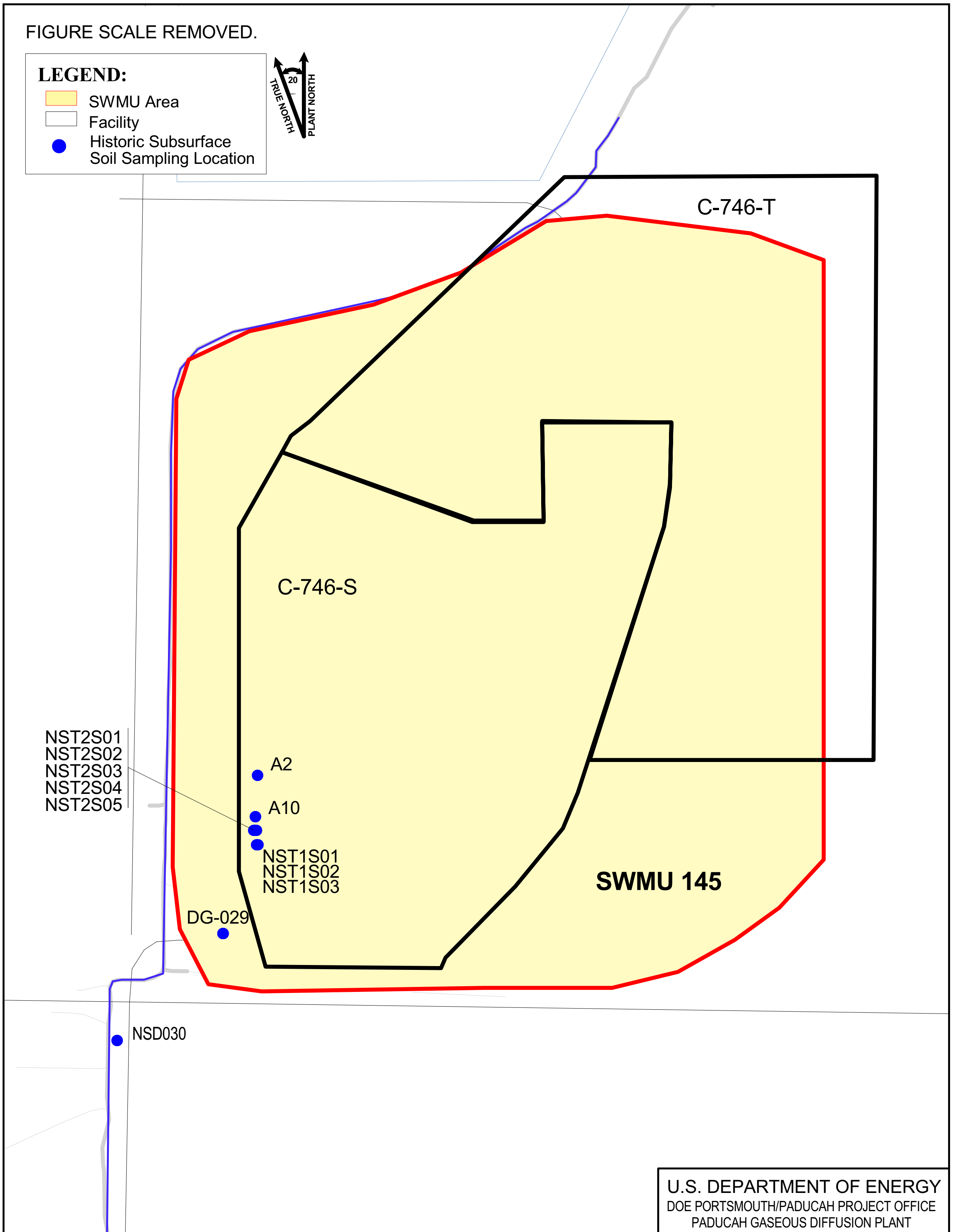

Figure 5.47. SWMU 145 Historical Subsurface Soil Sampling Locations

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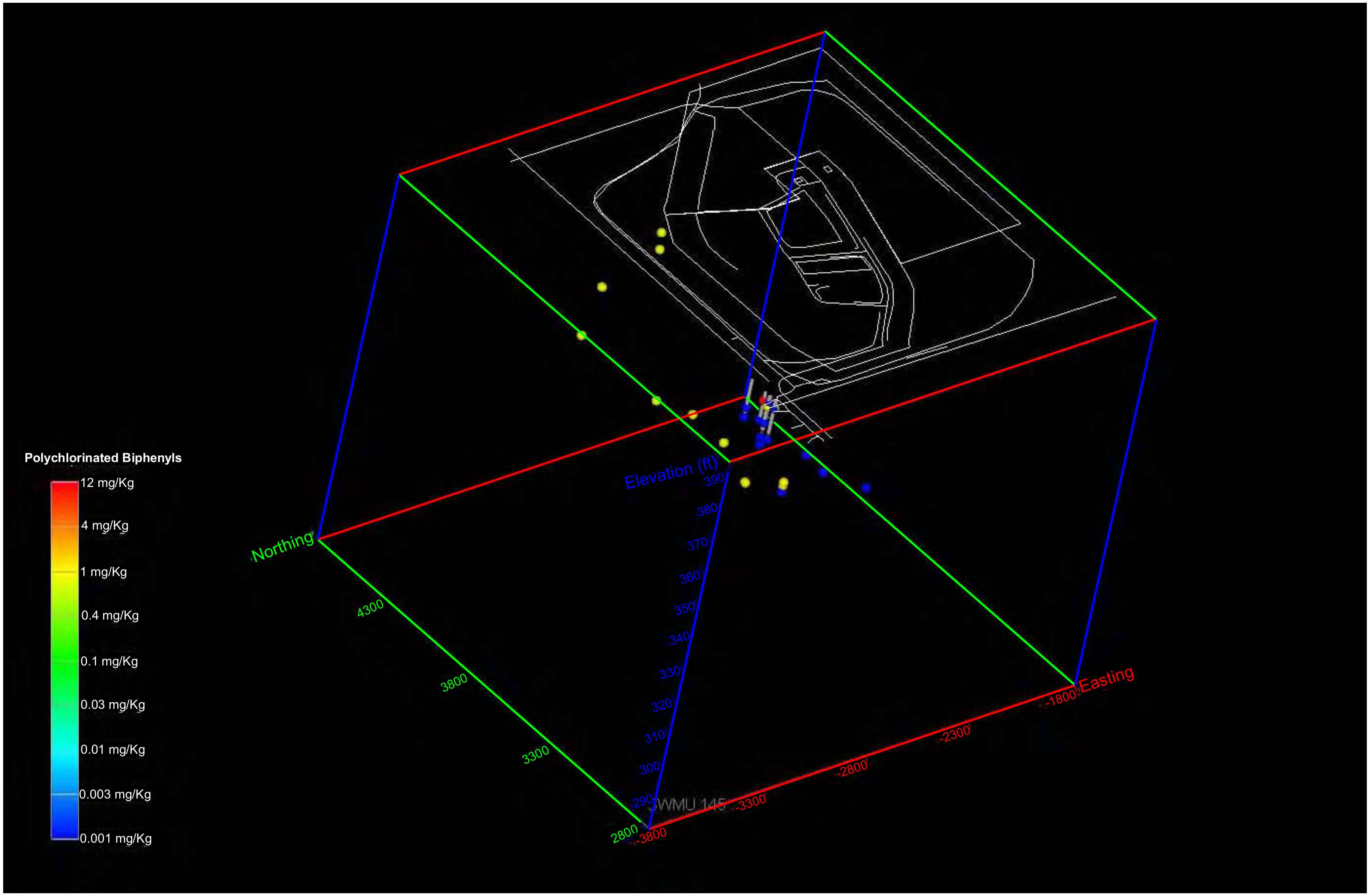

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Figure 5.48. SWMU 145 PCBs in Soil

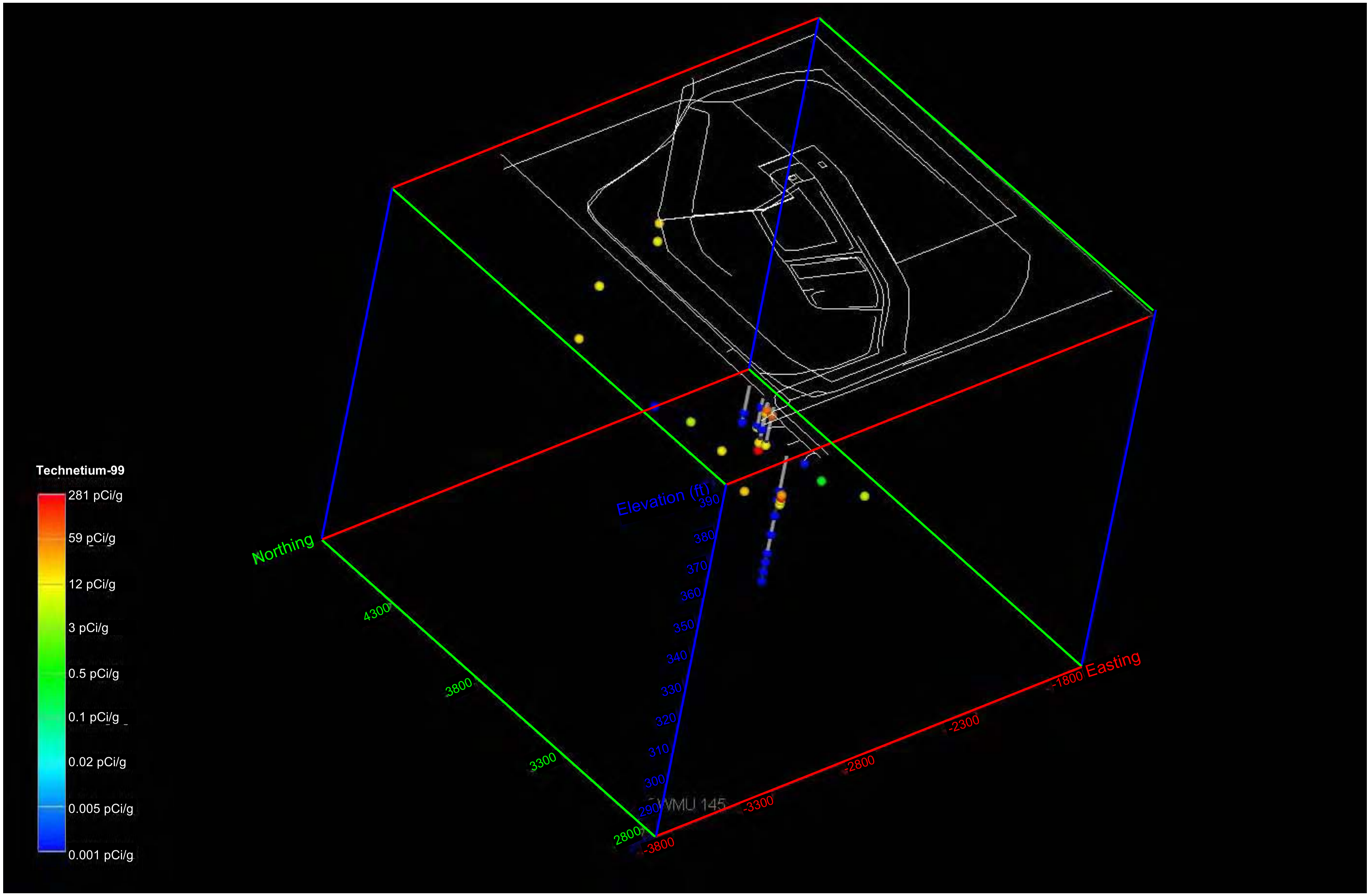

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Figure 5.49. SWMU 145 Technetium-99 in Soil

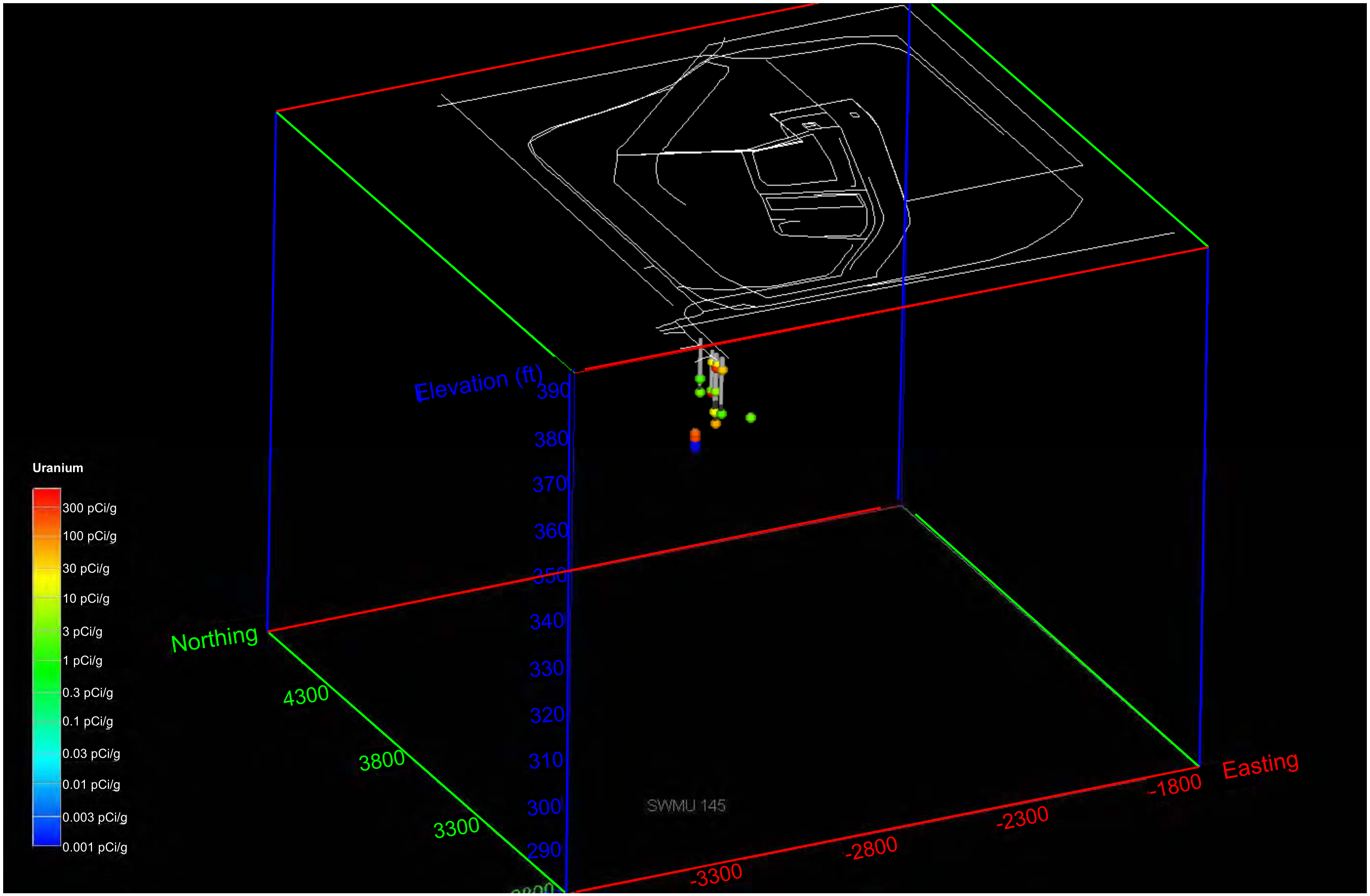

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Figure 5.50. SWMU 145 Total Uranium in Soil

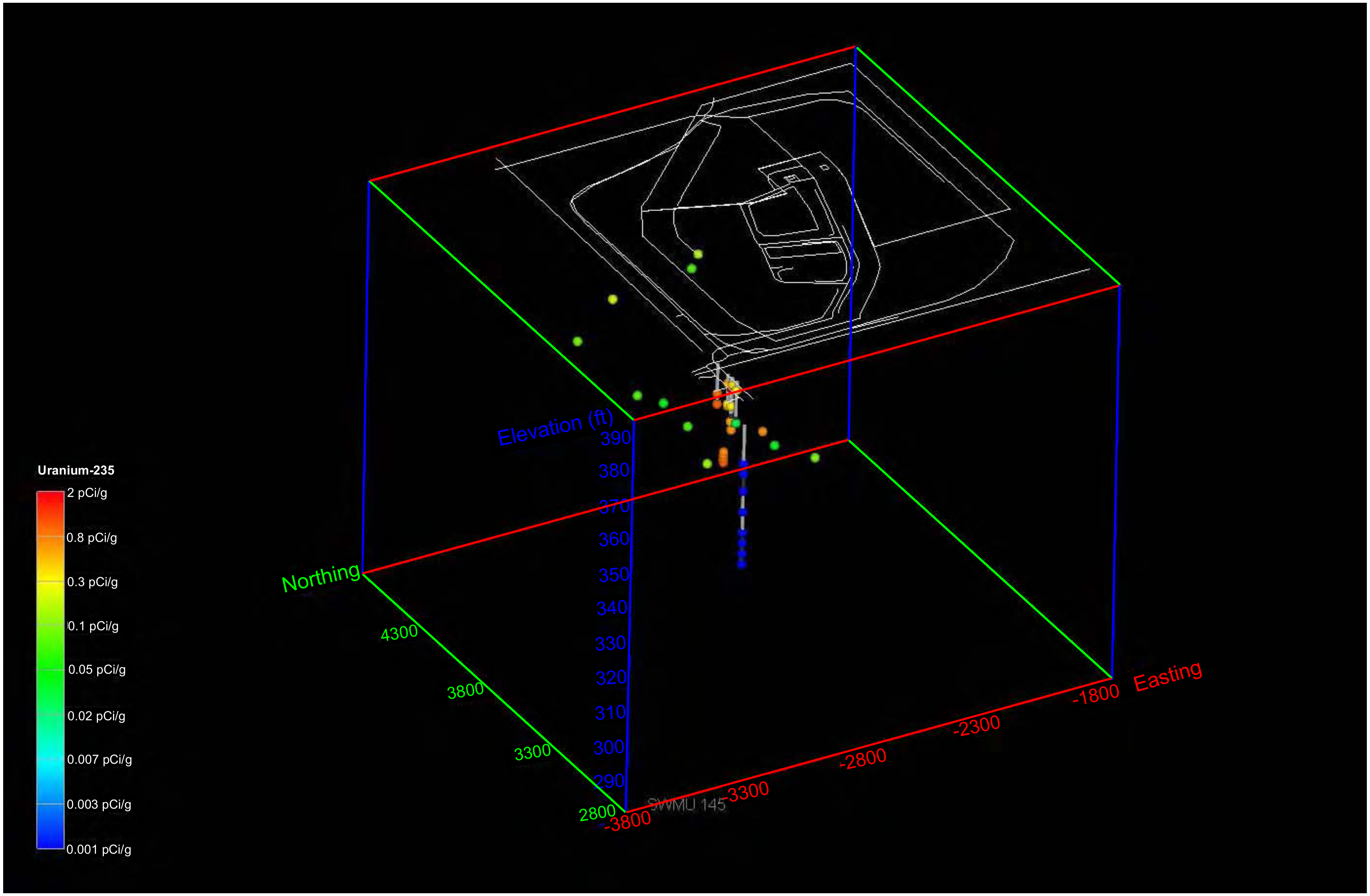

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Figure 5.51. SWMU 145 Uranium-235 in Soil

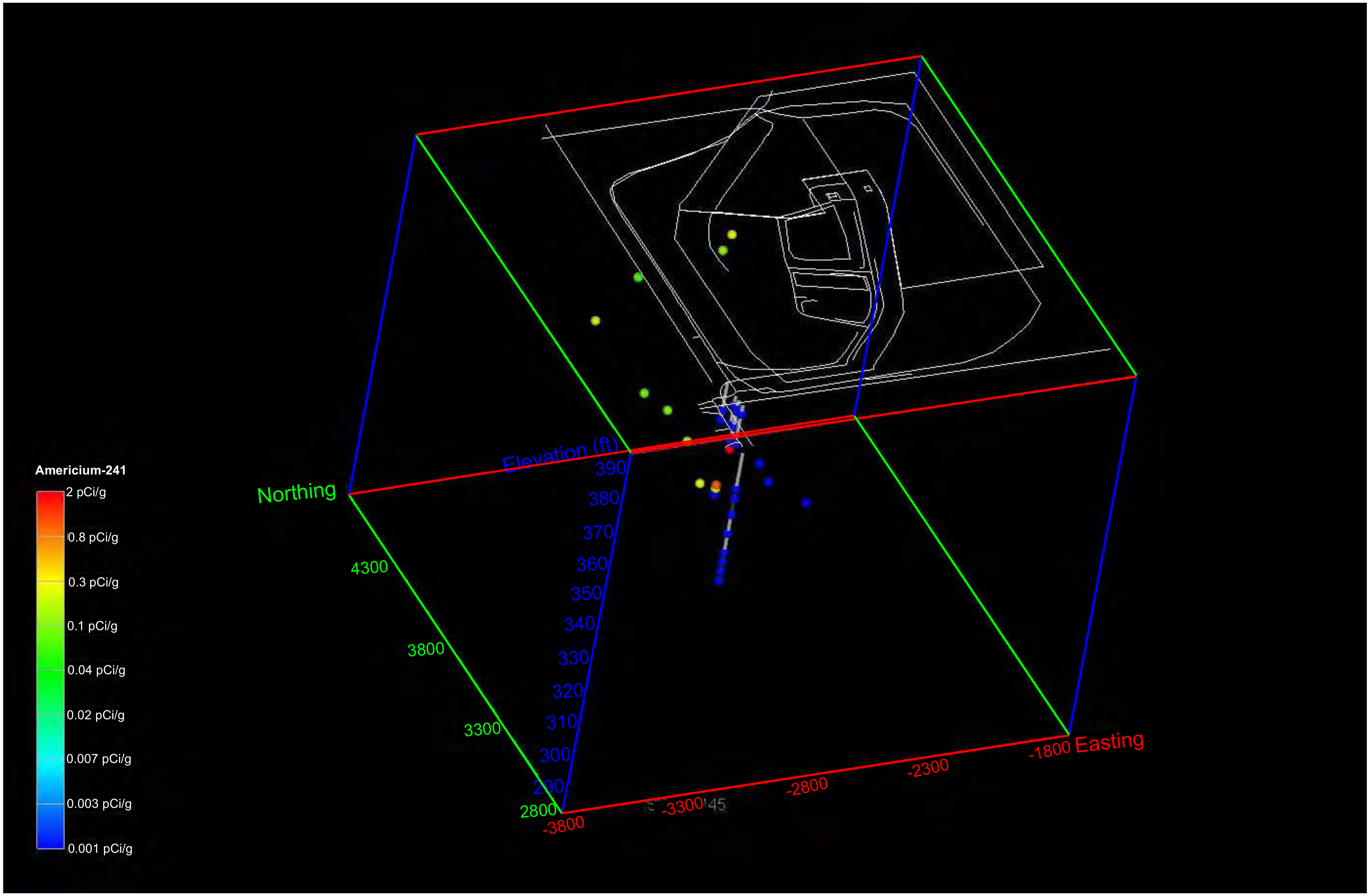

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Figure 5.52. SWMU 145 Americium-241 in Soil

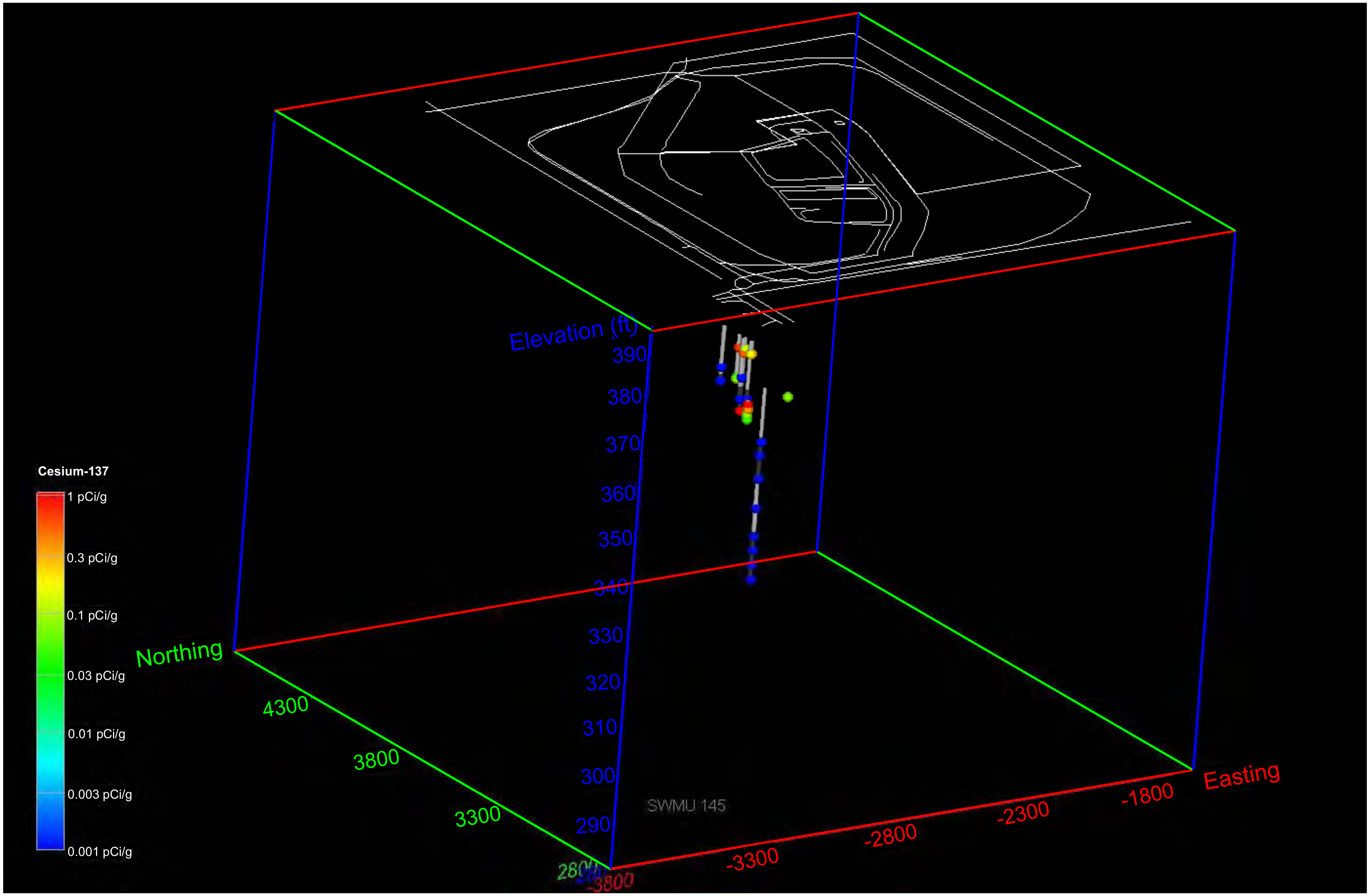

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Figure 5.53. SWMU 145 Cesium-137 in Soil

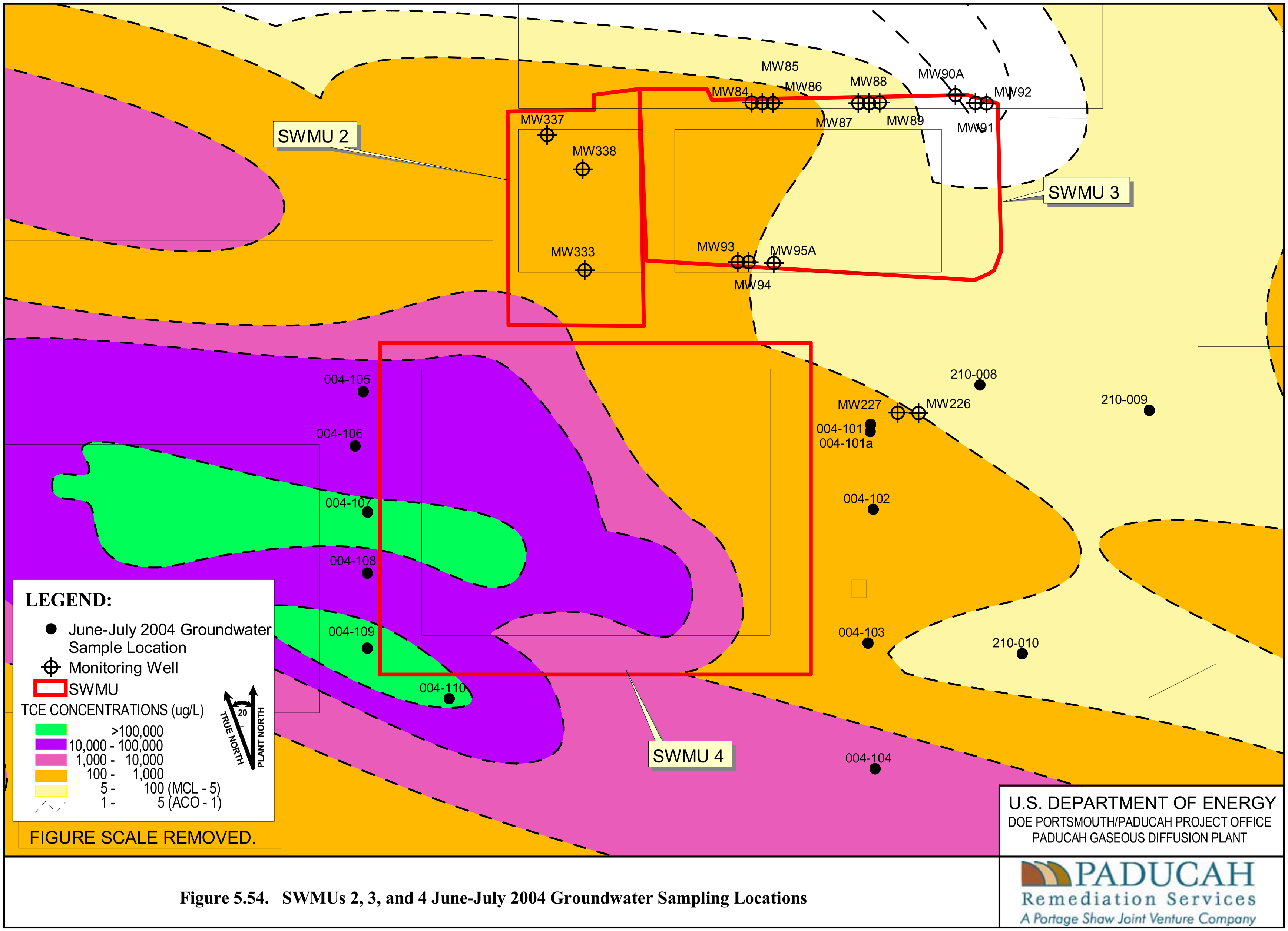

Figure 5.54. SWMUs 2, 3, and 4 June-July 2004 Groundwater Sampling Locations

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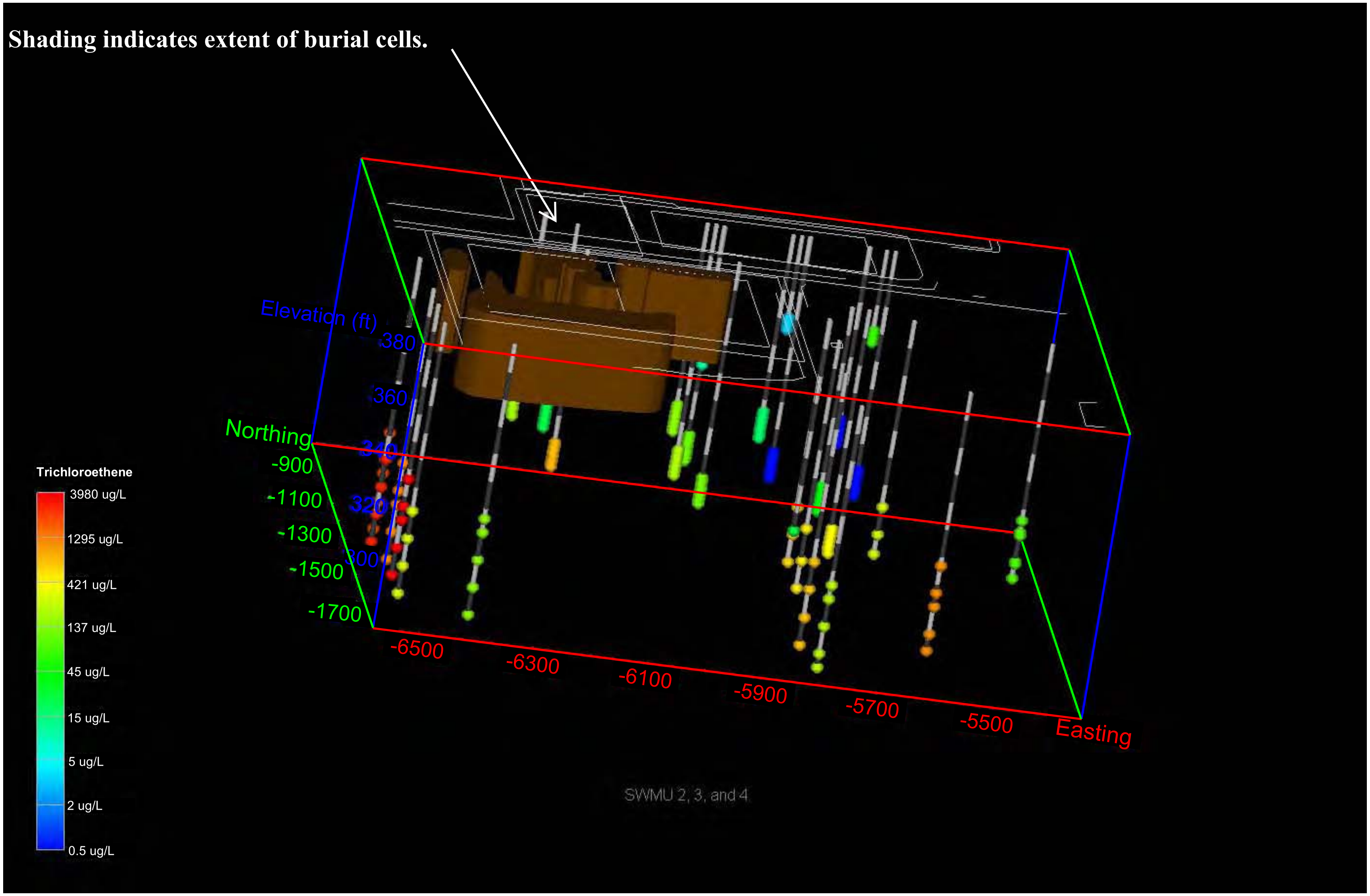

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Figure 5.55. SWMUs 2, 3, amd 4 TCE in Groundwater

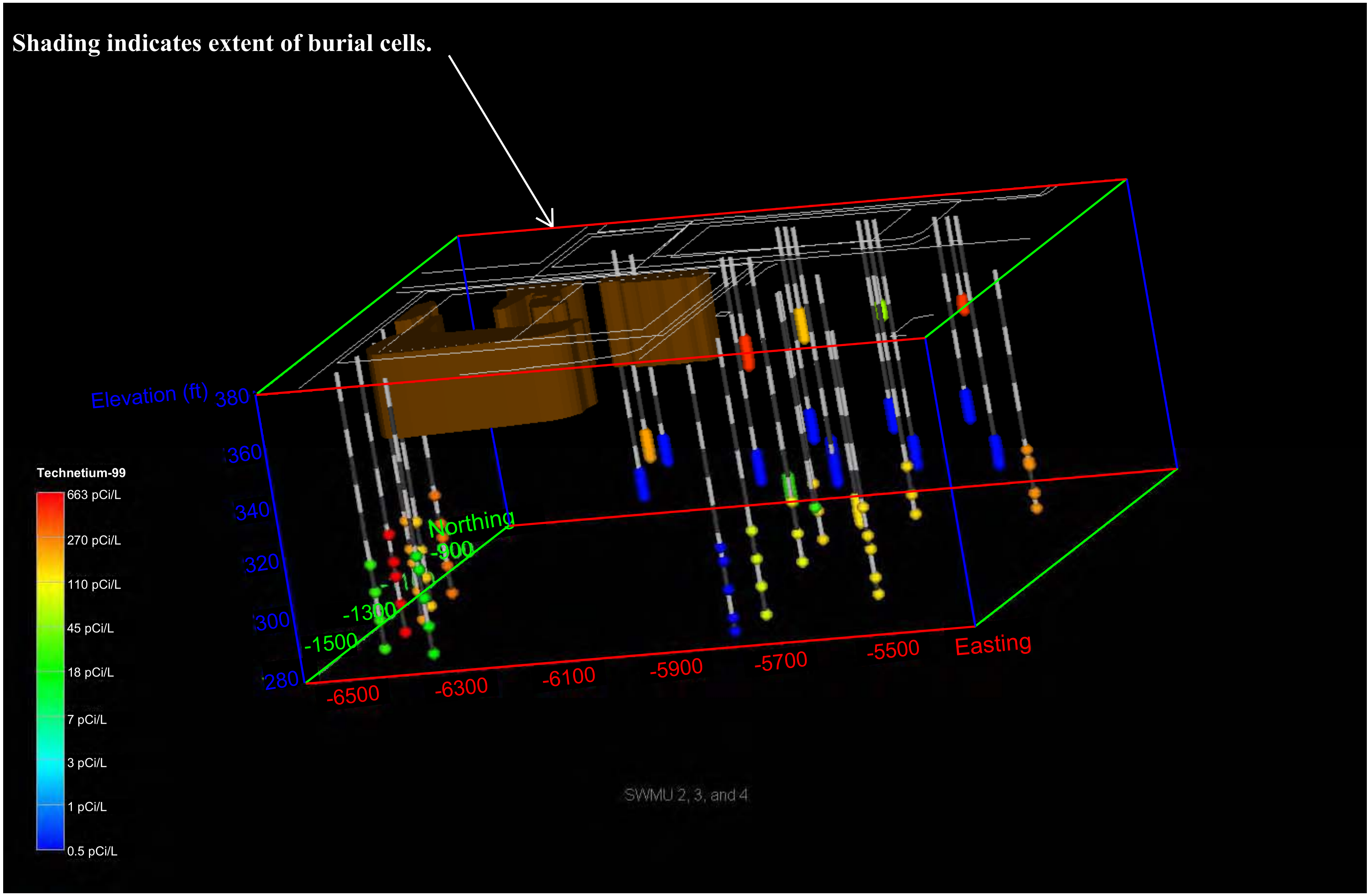

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Figure 5.56. SWMUs 2, 3, amd 4 Technetium-99 in Groundwater

This investigation determined, based on transport modeling, that TCE is the only contaminant potentially migrating from the current sources at SWMU 4 at a rate that may result in exceedances of the maximum contaminant level (MCL) at hypothetical points of exposure at the PGDP plant and property boundary. Metals and radionuclide contaminants may be migrating from SWMU 4 at rates that could result in exceedances of MCLs at the hypothetical points of exposure.

5.2.2.2 SWMUs 5 and 6

Figure 5.57 shows the groundwater sampling data points around SWMUs 5 and 6 associated with the historical OREIS data set described at the beginning of this chapter. Figures 5.58 and 5.59 show manganese and ^{237}Np contamination levels found in groundwater around these SWMUs. These parameters are shown due to a sufficient number of detectable results and at least one exceedance of a risk based comparison level.

Potential current and future migratory paths for SWMU 5 are restricted to material in the burial cells leaching out the cells. Migration from the cells is generally downward to the RGA, with potential lateral movement within the UCRS (see Section 6.2.3).

At the time of the WAG 3 RI, the primary concern for UCRS groundwater was radiological constituents, including ^{235}U, ^{238}U, ^{237}Np, ^{234}Th, and ^{99}Tc. Other potential contaminants in UCRS groundwater are acetone, TCE, and metals. The primary contaminants in the RGA groundwater were TCE and ^{99}Tc, but due to the proximity of SWMU 6 to the Northwest Plume, the presence of these contaminants is expected. In UCRS groundwater, ^{99}Tc was encountered ranging from 1,810 pCi/L at 9 ft bgs to 2,930 pCi/L at 12 ft bgs. Though these detections were sporadic and not by themselves indicative of widespread contamination, their presence may suggest that some contamination is moving vertically down. This observed migration is consistent with the conceptual model that postulates that contaminants will exit out the bottom of the burial cells and migrate downward through the UCRS and into the RGA. Contaminants found slightly above the MCL in SWMUs 5 and 6 groundwater samples were barium, beryllium, bis(2-ethylhexyl)phthalate (SWMU 5 only), cadmium, chromium, copper (SWMU 5 only), lead, mercury, and radium-226 (SWMU 5 only).

PCB-1016 was detected in the SWMU 6 UCRS groundwater samples from two of the soils borings. The concentrations were 53 μg/L (006-012) and 255 μg/L (006-011).

5.2.2.3 SWMUs 7 and 30

Figure 5.60 shows the groundwater sampling data points around SWMUs 7 and 30 associated with the June–July 2004 groundwater sampling described at the beginning of this chapter. Figures 5.61 and 5.62 show TCE and ^{99}Tc contamination levels found in groundwater around these SWMUs. Only TCE and ^{99}Tc modeling is provided as these are typical contaminants of concern for PGDP SWMUs. Appendix E provides data for all parameters that have been identified in groundwater in SWMUs 7 and 30.

Metals and uranium (at high activities) contaminate water from Burial Pits B, C, and F. The groundwater from Burial Pits B and C also is contaminated with benzene, toluene, ethyl benzene, and xylene (BTEX) compounds and fuel-related SVOCs (possibly from equipment that was disposed), as well as vinyl chloride. Water from Burial Pit F contains low levels of VOCs. In contrast, the primary UCRS contaminants are TCE and its degradation products, essentially with no uranium. Groundwater from the RGA is contaminated with TCE at high concentrations, indicative of a DNAPL occurrence. High-dissolved TCE levels near the base of the RGA are attributable to PGDP's Northwest Plume, which is

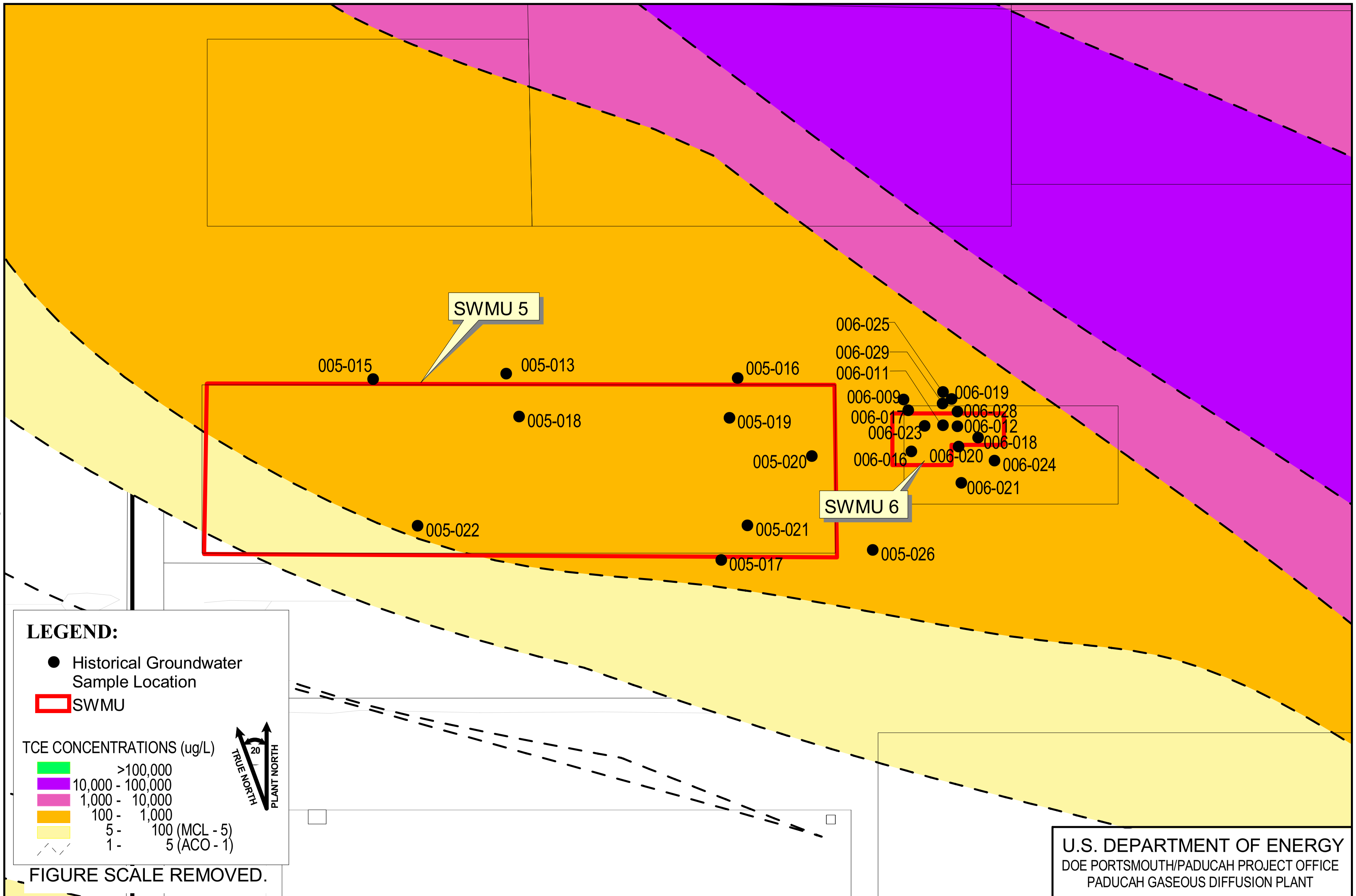

Figure 5.57. SWMUs 5 and 6 Historical Groundwater Sampling Locations

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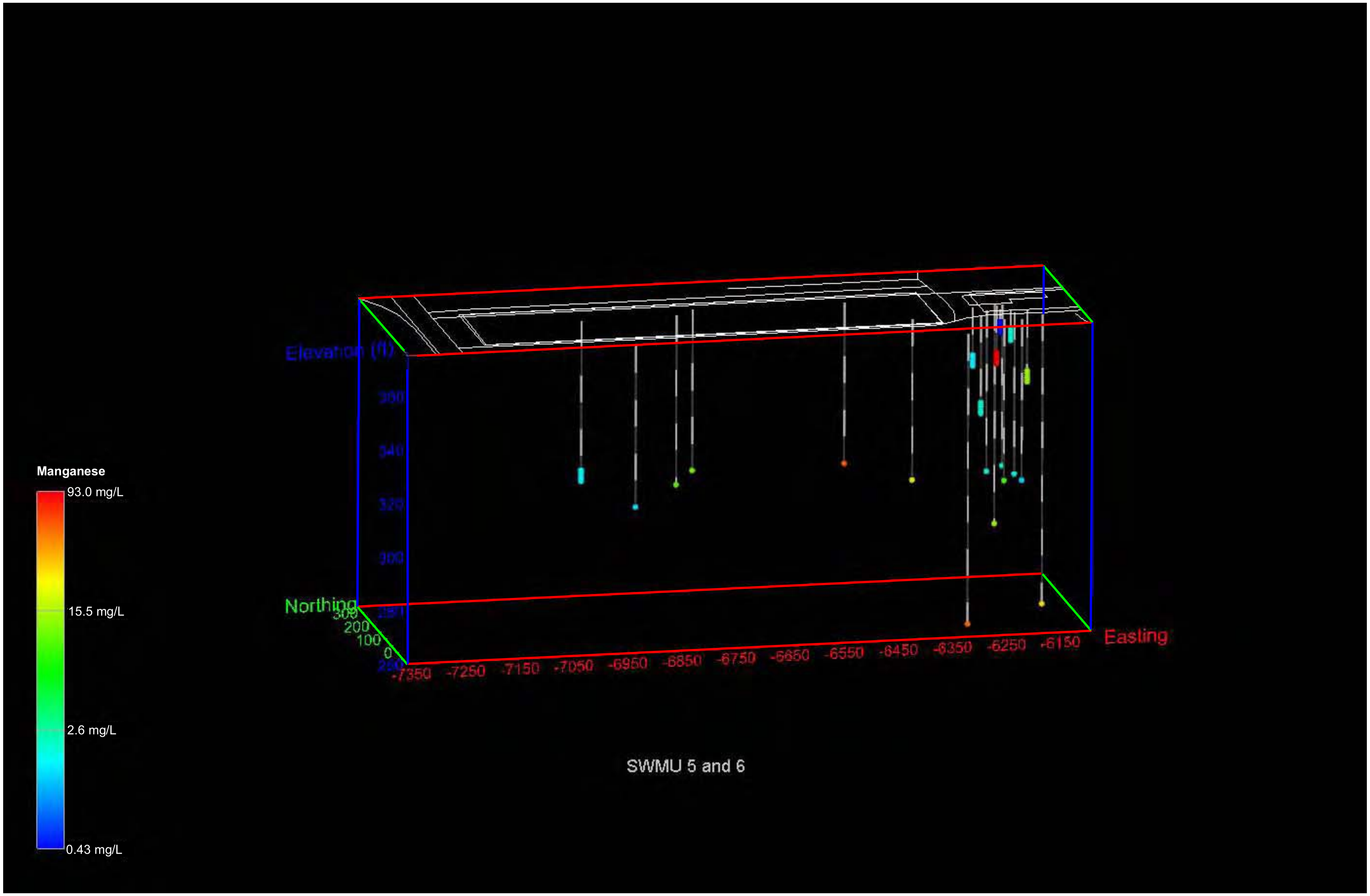

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Figure 5.58. SWMUs 5 and 6 Manganese Groundwater

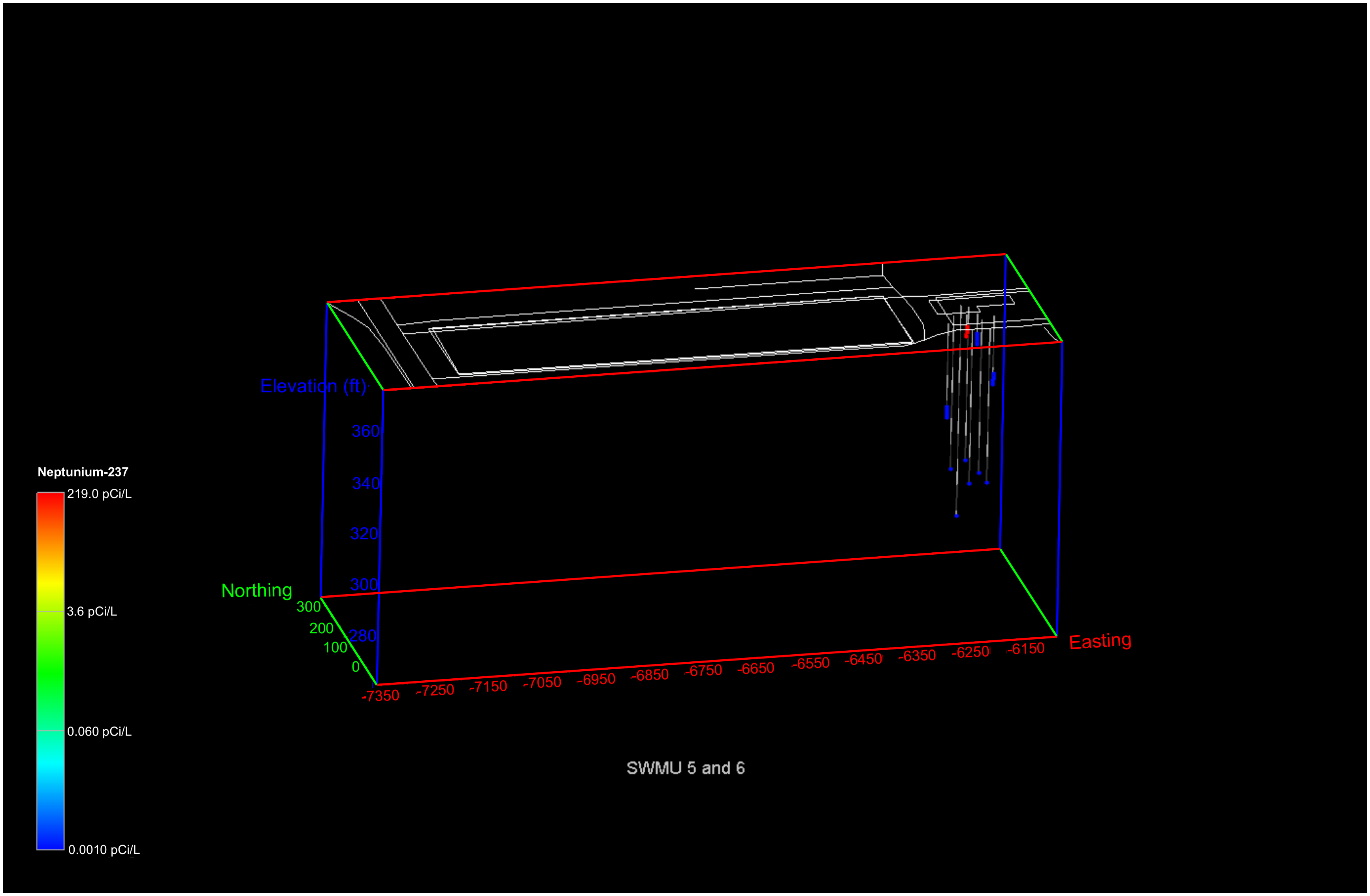

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Figure 5.59. SWMUs 5 and 6 Neptunium-237 in Groundwater

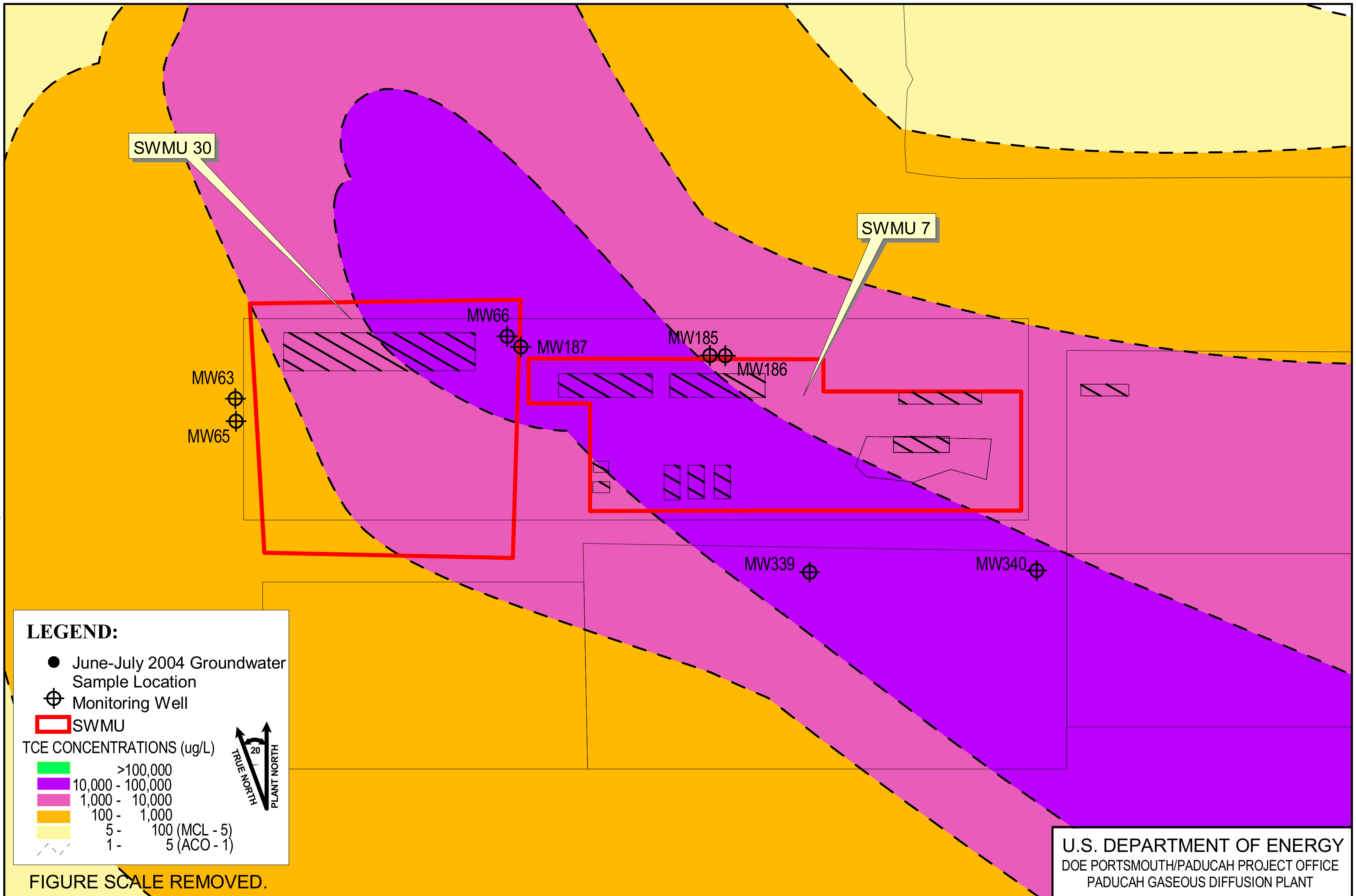

Figure 5.60. SWMUs 7 and 30 June-July 2004 Groundwater Monitoring Locations

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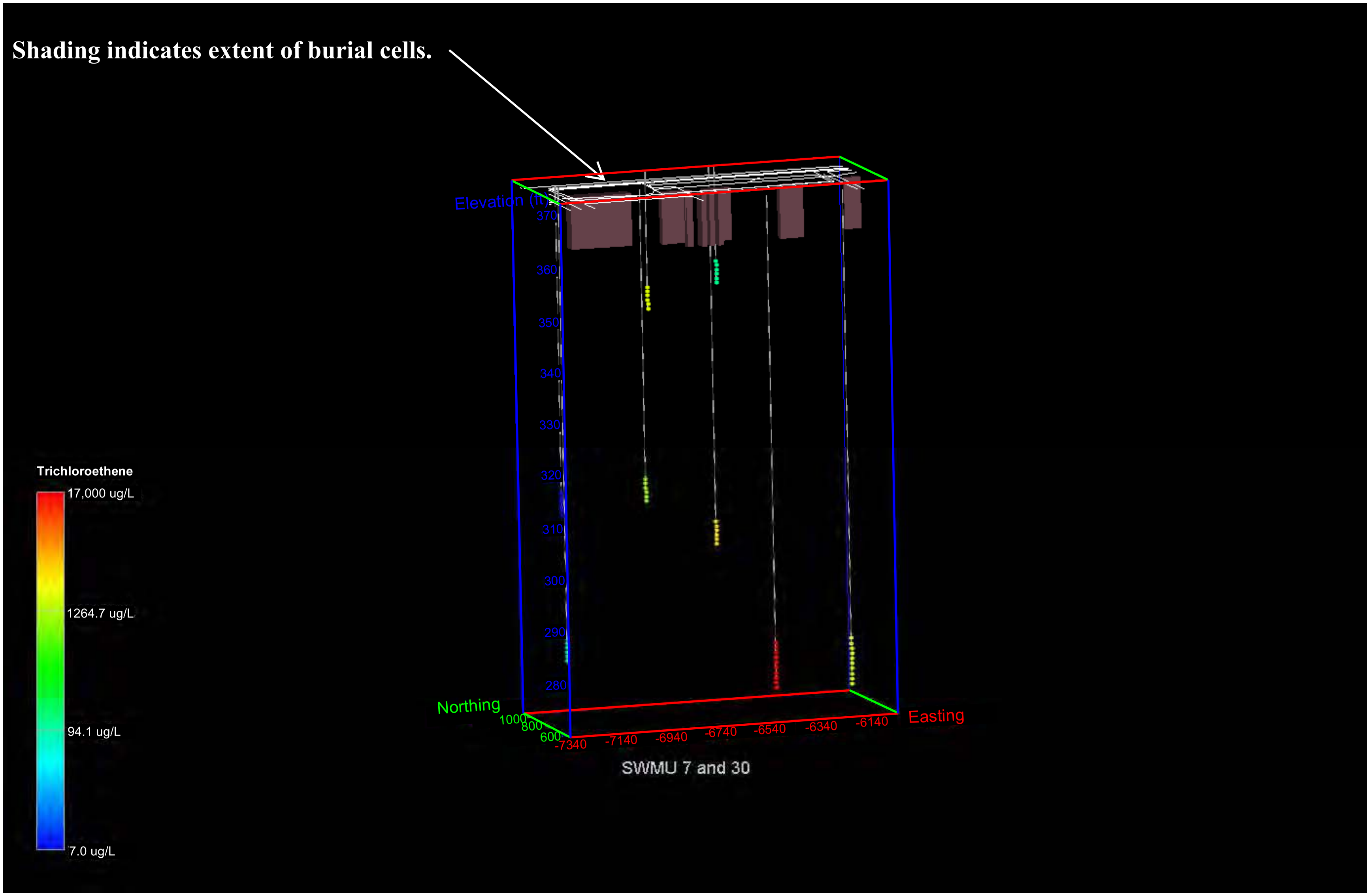

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Figure 5.61. SWMUs 7 and 30 TCE in Groundwater

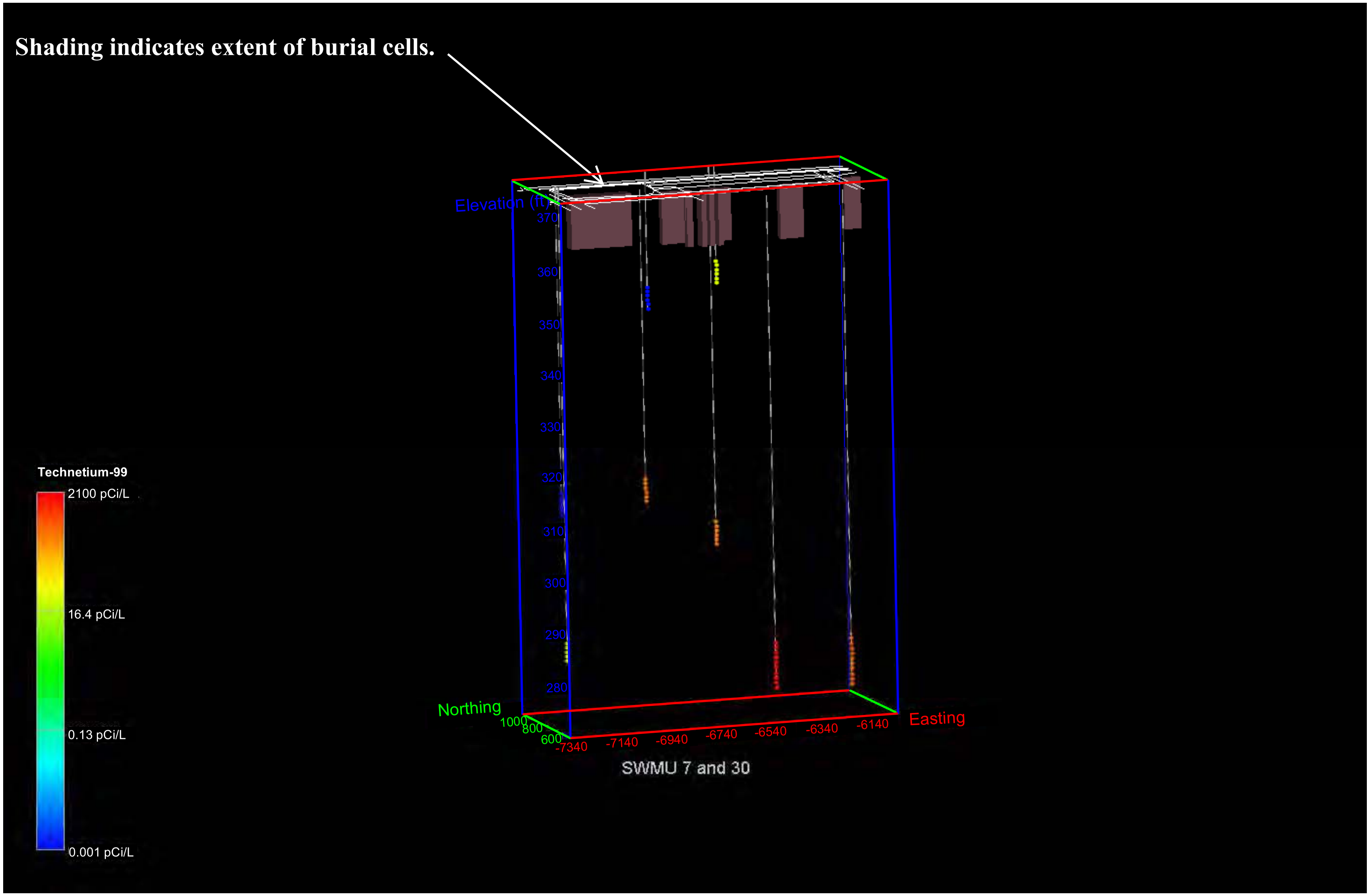

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Figure 5.62. SWMUs 7 and 30 Technetium-99 in Groundwater

sourced from a DNAPL at the C-400 Building, located upgradient of SWMU 7. The variability of TCE levels in samples from MW 66, located north of SWMU 7, suggests the possibility of a SWMU 7 DNAPL source for contamination in the upper RGA. This variability also may be due to the Northwest Plume.

Metals, radionuclides, BTEX compounds, and TCE degradation products contaminate water in Burial Pit A. Despite high activities of uranium in some Pit A water samples, elevated uranium activity is not detectable in the adjacent UCRS. TCE contamination of the UCRS and RGA at SWMU 30 may be derived from local sources. However, any DNAPL that may be present has migrated into the underlying soils and is now distinct from the burial pits.

5.2.2.4 SWMU 145

Figure 5.63 shows the groundwater sampling data points around SWMU 145 associated with the June–July 2004 groundwater sampling described at the beginning of this chapter. Figures 5.64 and 5.65 show TCE and ^{99}Tc contamination levels found in groundwater around these SWMUs. Only TCE and ^{99}Tc modeling is provided as these are typical contaminants of concern for PGDP SWMUs. Appendix E provides data for all parameters that have been identified in groundwater in SWMU 145.

In 2001, a scoping package was prepared that included SWMU 145 related to the entire C-746-S&T Landfill area (BJC 2001). This package summarized data available from the area near this SWMU in both soil and groundwater media. The scoping was used to develop the *Site Investigation Work Plan for the C-746-S&T Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2003c). This project was completed in 2004 in accordance with this plan. The primary focus of the sampling strategy was to collect sufficient groundwater data to determine the following:

> Is all of the TCE and ^{99}Tc detected in the groundwater MWs in the area of the C-746-S&T Landfill originating from upgradient sources?

Data from this investigation is included in the groundwater data set from the June through July 2004 sampling activities (DOE 1995) that has been evaluated during development of this work plan.

5.2.3 Surface Water/Sediment

A summary of existing surface water data is provided in the *Scoping Document for the Burial Grounds Operable Unit Remedial Investigation/Feasibility Study at Paducah Gaseous Diffusion Plant Paducah, Kentucky* (DOE 2004b). No surface water samples have been collected at SWMUs 2, 3, 4, 5, and 6 due to the shallow ditches surrounding the areas, which are typically dry. There are seven historical surface water sampling locations for SWMUs 7 and 30 and six for SWMU 145. None of these samples exceeded action levels for any analytes.

During July through September, 2005 sampling was completed in accordance with the *Sampling and Analysis Plan for Site Investigation and Risk Assessment of the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah Kentucky,* DOE/OR/07-2137&D2/R2. The scope of this project included collection sediment or soil samples, which were taken less than 6 in. bgs, from the internal plant ditches and the NSDD. Figure 5.66 shows the location of these samples. As discussed in Section 1.1 of this work plan, evaluation of these areas (which surround the burial grounds) will be included in the SWOU evaluation.

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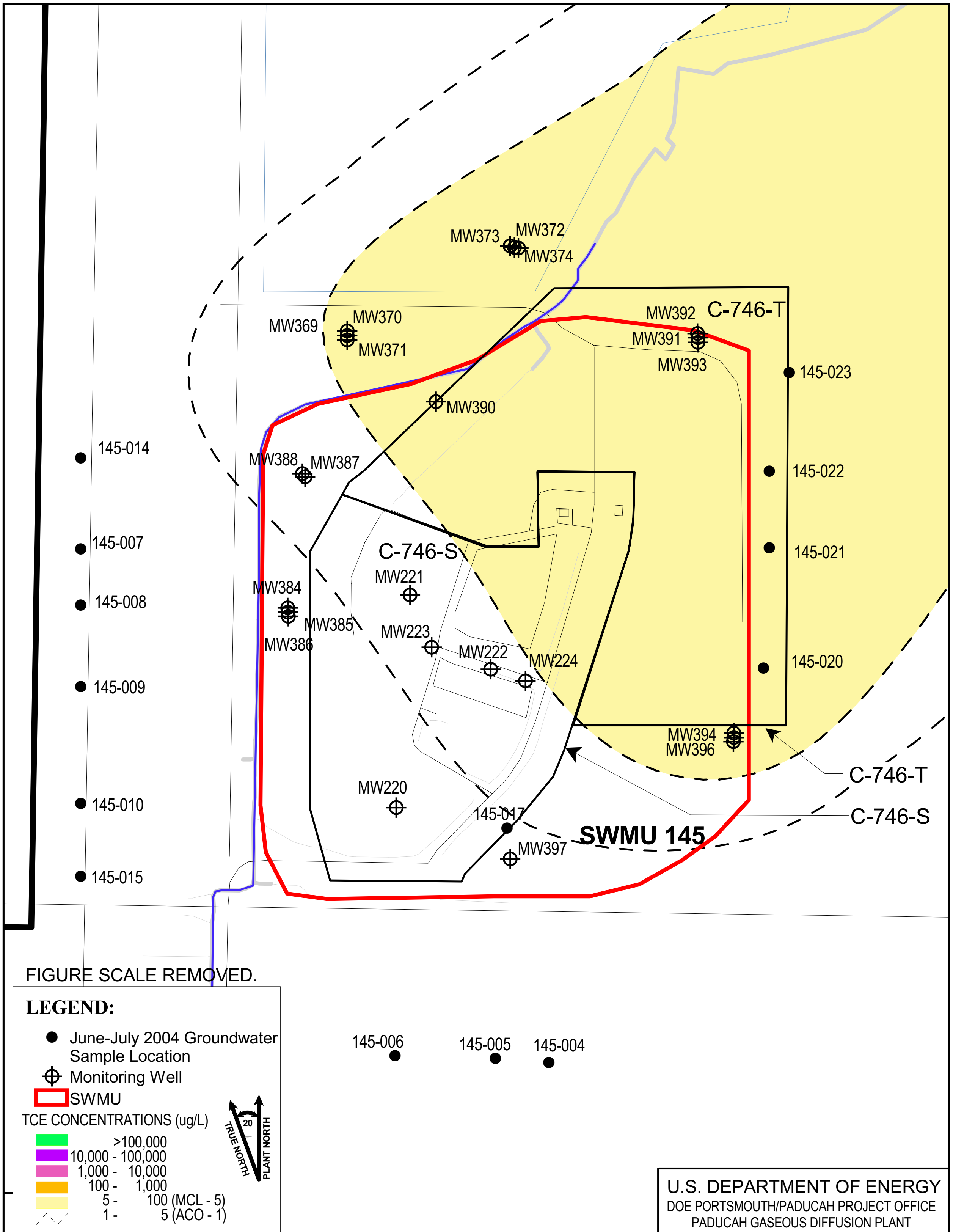

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Figre 5.63. SWMU 145 June-July 2004 Groundwater Sampling Locations

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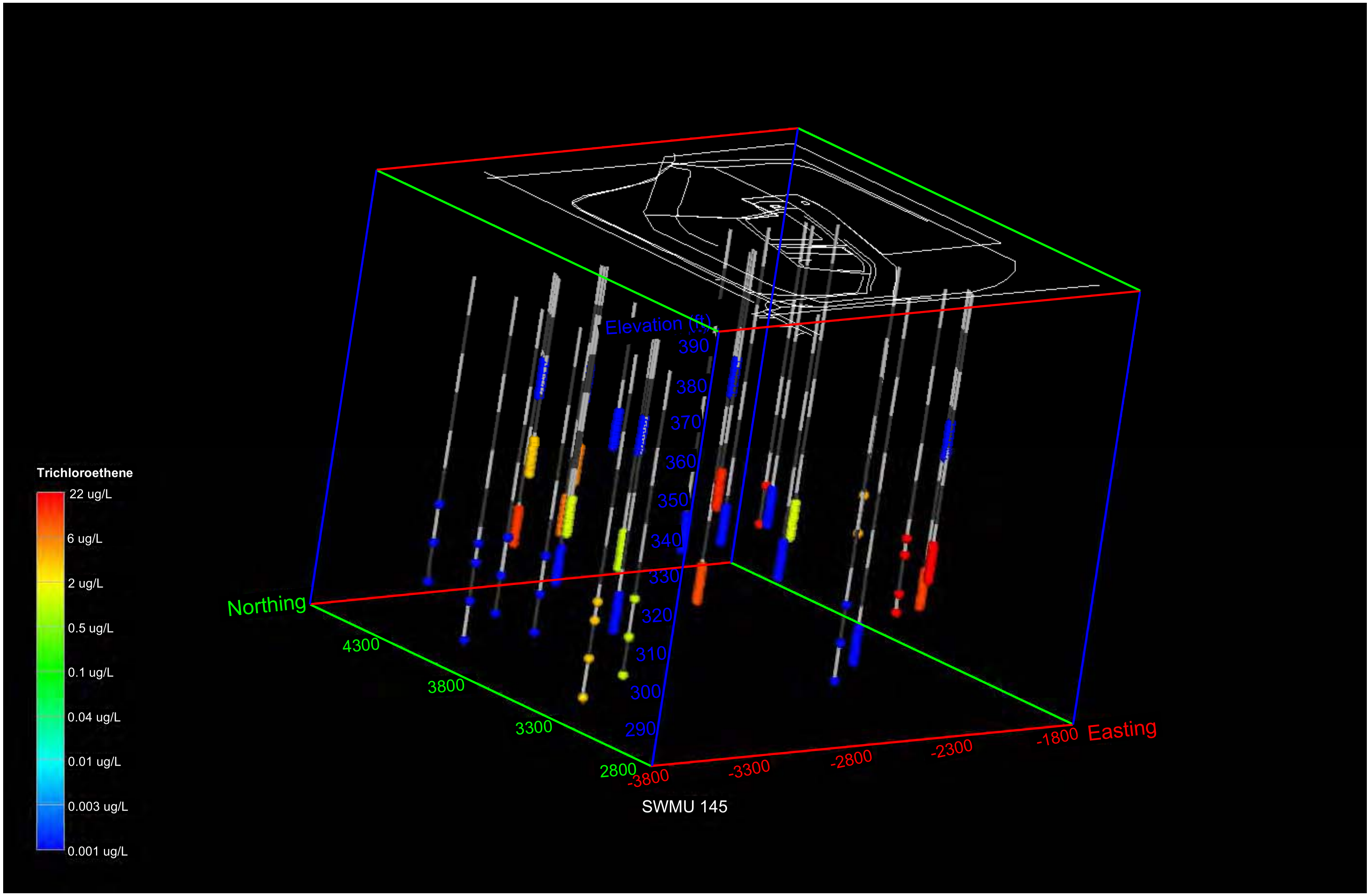

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Figure 5.64. SWMU 145 TCE in Groundwater

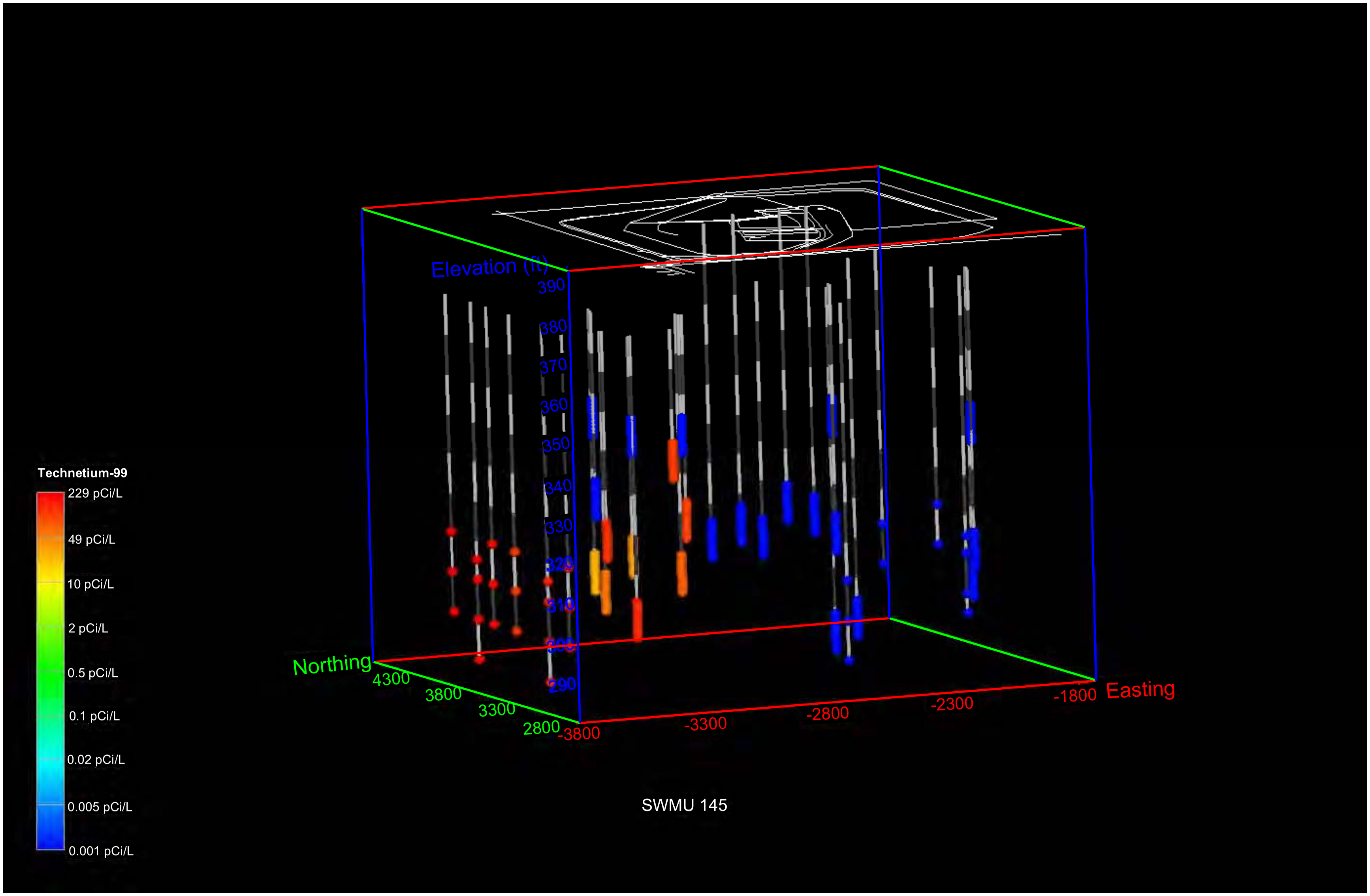

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Figure 5.65. SWMU 145 Technetium-99 in Groundwater

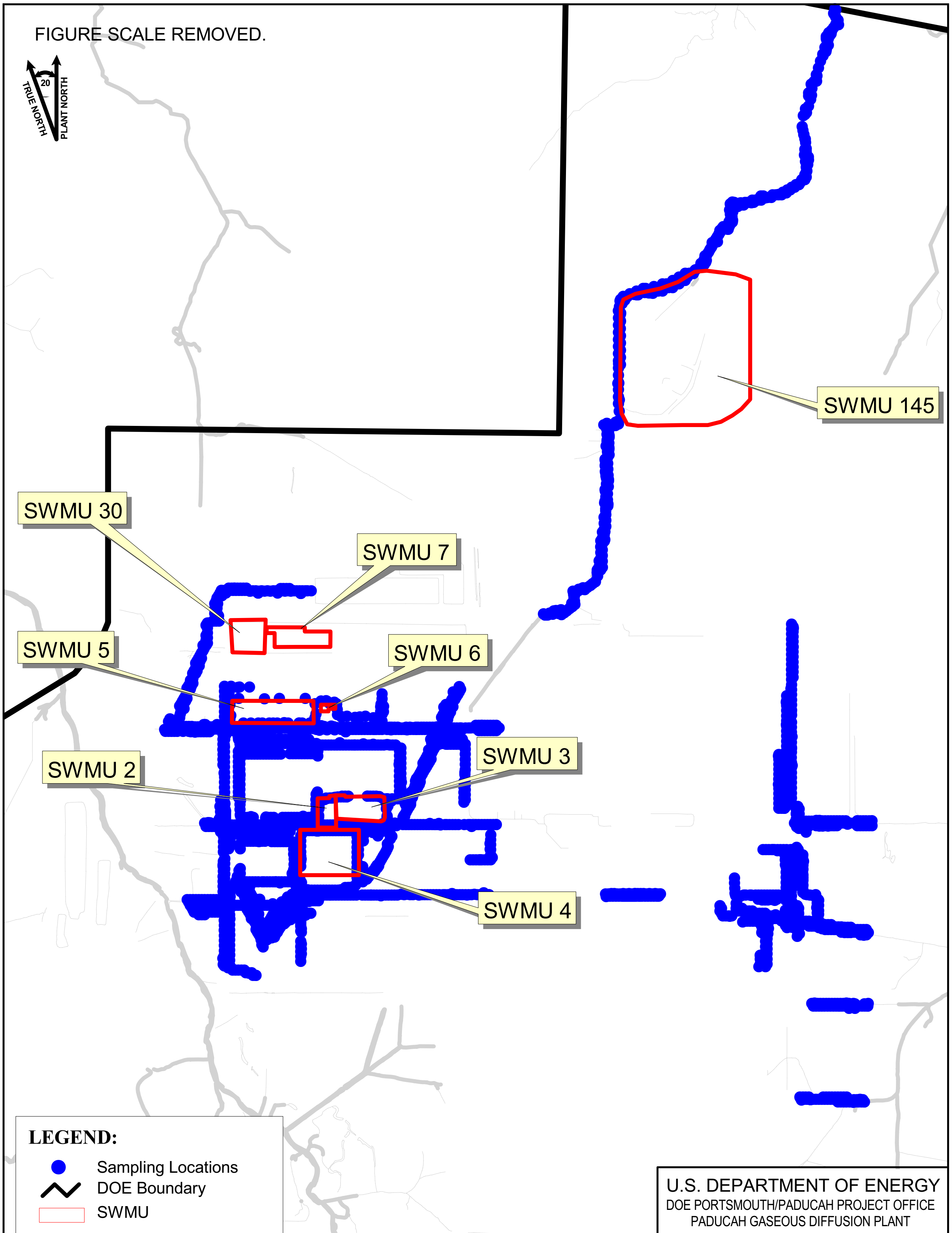

Figure 5.66. SWOU Sediment Sampling Locations

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6. INITIAL EVALUATION

6.1 RISK ASSESSMENT

When fieldwork is completed and data have been verified, validated, assessed, and evaluated, a BGOU RI/FS Report will be written. The primary purpose of this report will be to present the results from the field investigation; however, this report also will include interpretations of the results using various modeling and mapping approaches. The approaches used will be dependent on the nature of the data and the results obtained. In particular, the report will focus on the nature and extent of contamination found and the potential for migration of this contamination.

Using the presentations and interpretations of the results, the decision rules developed during the DQO process will be addressed, and the various statistical assumptions forming the basis of the sampling plan will be verified. Appendix D presents the general report outline for the RI/FS Report. The outline for the BRA is presented in Table 6.1.

The BHHRA will identify chemicals of potential concern (COPCs); assess pathways of exposure under residential, industrial, and recreational use; assess the toxicity of COPCs; characterize the risk posed by COPCs; select COCs, pathways of concern, and use scenarios of concern; discuss uncertainties affecting risk estimates; and calculate remedial goal options (RGOs) for all COCs. The BHHRA will be completed consistent with guidance in Chapter 3 of Vol. 1 of the PGDP Risk Methods Document (DOE 2000b). This will include completion of fate and transport modeling consistent with the risk assessment modeling matrix and generation of information that can be incorporated in the PGDP site-wide risk assessment model (DOE 2003c).

To support the risk evaluation, and consistent with the PGDP Risk Methods Document (DOE 2000), probabilistic fate and transport modeling may be employed. The use of this modeling helps account for uncertainties in the size of the source zones and transport parameters and allows an evaluation of error bounds. These modeling tools may include the Statistical Analysis and Decision Assistance (SADA), Seasonal Soil Compartment (SESOIL); and Analytical Transient 1-,2-,3- Dimensional (AT123D). SADA is used to refine source zones. SESOIL is a leaching model used to estimate the time-variant contaminants loading from each source area to the RGA. AT123D is used to complete saturated flow and contaminants transport modeling.

6.1.1 Data Evaluation

Documentation for the BGOU RI/FS also will include a BRA. The BRA will include, at minimum, a complete BHHRA that is consistent with methods presented in Chapter 3 of Vol. 1 of the PGDP Risk Methods Document (DOE 2000b) and a SERA consistent with methods presented in Vol. 2 of the PGDP Risk Methods Document (DOE 2000d). The BRA will use all historical data representative of current site conditions, as well as the data collected during the field investigation described in this work plan. The objectives of the BRA will include the following:

- Evaluate the potential threat to human health in the absence of any action.
- Provide at least a preliminary evaluation of harm to ecological resources in the absence of any action.

Table 6.1 Baseline Risk Assessment Outline

Baseline Human Health Risk Assessment

1. Results of Previous Studies
2. Identification of Chemicals of Potential Concern
   - 2.1 Sources of Data
   - 2.2 General Data Evaluation Considerations
   - 2.3 Risk Assessment Specific Data Evaluation
   - 2.4 Evaluation of Data from Other Sources
   - 2.5 Summary of Chemicals of Potential Concern
3. Exposure Assessment
   - 3.1 Characterization of Exposure Setting
   - 3.2 Identification of Exposure Pathways
   - 3.3 Quantification of Exposure
   - 3.4 Summary of Exposure Assessment
4. Toxicity Assessment
   - 4.1 Inorganics
   - 4.2 Organics
   - 4.3 Radionuclides
   - 4.4 Chemicals for Which No EPA Toxicity Values Are Available
   - 4.5 Uncertainties Related to Toxicity Assessment
   - 4.6 Summary
5. Risk Characterization
   - 5.1 Determination of Noncancer Effects
   - 5.2 Determination of Excess Cancer Risk
   - 5.3 Risk Characterization for Current Use Scenario(s)
   - 5.4 Risk Characterization for Future Use Scenario(s)
   - 5.5 Risk Characterization for Lead (if needed)
   - 5.6 Identification of Use Scenarios, Contaminants, Pathways, and Media of Concern
   - 5.7 Summary of Risk Characterization
6. Uncertainty in the Risk Assessment
   - 6.1 Uncertainties Associated with Data
   - 6.2 Uncertainties Associated with Exposure Assessment
   - 6.3 Uncertainties Associated with Toxicity Assessment
   - 6.4 Uncertainties Associated with Risk Characterization
   - 6.5 Summary of Uncertainties
7. Conclusions and Summary
   - 7.1 Chemicals of Potential Concern
   - 7.2 Exposure Assessment
   - 7.3 Toxicity Assessment
   - 7.4 Risk Characterization
   - 7.5 Observations

Screening-Level Ecological Risk Assessment

(The outline of the SERA will be consistent with the completion of Steps 1, 2, and 3 of the EPA ecological risk assessment process as outlined in Vol. 2 of the PGDP Risk Methods Document (DOE 2000d). This outline for the ecological risk assessment is dependent on the amount of information available after completion of field activities; therefore, the outline will be determined at that time.)

- Provide a basis for determining if a response action is necessary or justified.

- Provide the information needed to determine what concentrations of chemicals and radionuclides are considered protective of human health and the environment.

- Provide a baseline for comparing the level of protection from various response alternatives relative to potential human health and ecological effects.

To meet these objectives, the risk assessment will identify and characterize the following items:

- Levels of hazardous substances present in relevant media, including a review of relevant biological and chemical information, and the potential changes in concentration and activities of hazardous substances in relevant media over time.

- Potential exposure pathways and routes and the extent of actual or predicted exposure.

- Potential human receptors by defining the size, characteristics, and location of human populations that may be exposed to contaminants at or migrating from the study areas.

- Extent of potential impact by quantifying potential carcinogenic risk and systemic toxicity.

- Potential ecological harm within the study area from exposure to contaminants at or migrating from the study areas.

- Levels of uncertainty associated with the assessment, including a summary of the strengths and weaknesses of site characterization, toxicity assessment, exposure assessment, and health risk characterization. The summary will include a discussion of the effect of the major assumptions made during risk characterization upon the resulting risk values. Uncertainty analysis may include sensitivity or other quantitative analyses if these are deemed necessary for forthcoming response action decisions.

6.1.2 Exposure Assessment

This section of the exposure assessment will delineate the pathways through which the receptors may be exposed under both current and future conditions. The exposure assessment will be conducted in accordance with *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Vol. 1: Human Health* (DOE 2000b). The goal of this material will be to provide a complete depiction of all exposure pathways for current and future uses. To achieve this goal, this section will present conceptual site models and supporting text. Also, in this section, each pathway will be described in terms of source, route of exposure, exposure point, and receptor. This format will be followed, because all four must be present for a complete pathway to exist.

Exposure assessments in BHHRAs completed in the past indicate that at least 24 exposure pathways should be considered as potential pathways in all assessments. Additional pathways, such as contact with buried waste, may be reasonable for some units or areas. Further, exposure assessments will be performed on a range of worker exposure times if the selected exposure time deviates significantly from the assumptions in the Methods Document. Worker exposure will be evaluated more fully in the feasibility study when the hazards of implementing a potential remedial action are more fully analyzed.

6.1.3 Toxicity Assessment

The primary purpose of this section of the BHHRA will be to report the toxic effects of the COPCs on exposed populations. The toxicity assessment will be conducted in accordance with *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Vol. 1. Human Health* (DOE 2000b). In addition, this section will briefly describe the methods used by EPA, and in the toxicity assessment, to develop toxicity parameters, delineate the sources used to acquire the toxicity parameters, and present tables summarizing the toxicity information used in the risk assessment. In closing, this section will summarize the amount of toxicity information available on the COPCs in the risk assessment and discuss general toxicity assessment uncertainties.

6.1.4 Risk Characterization

The primary purpose of this section of the BHHRA will be to integrate the dose information developed in the exposure assessment with the effects information presented in the toxicity assessment to characterize the risks and hazards posed by environmental contamination at PGDP. The risk characterization will be conducted in accordance with *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Vol. 1: Human Health* (DOE 2000b). In this section, the following items will be presented: the methods used to integrate the information to characterize risks and hazards and the tables and a narrative summarizing the risk characterization for each exposure unit under each current and potential future use scenario. This section will conclude with a listing of use scenarios of concern for each location and a listing of COCs, pathways of concern, and mediums of concern for each use scenario of concern.

6.1.5 Preliminary Remediation Goals (Risk Assessment Guidance for Superfund, Vol. 1, Part B)

Chemical-specific PRGs are concentration goals for individual chemicals in specific medium and land use combinations, which are used by risk managers as long-term targets during the analysis and selection of remedial alternatives. Chemical-specific PRGs are from two general sources. These are (1) concentrations based on ARARs and (2) concentrations based on risk assessment. The chemical-specific PRGs discussed in this document are concentrations based on human health risk assessment. However, concentrations based on ARARs and ecological risk assessment are discussed and presented elsewhere within the Risk Assessment Information System.

Chemical-specific PRGs also can be used as screening tools. Screening against chemical-specific PRGs and other limiting criteria is discussed in the Remedial Site Evaluation Report as a preliminary step in the RI/FS process. Comparisons can be used to focus concern on a specific medium or COPC and support "no further action" recommendations. In addition, chemical-specific PRG screens can be used as toxicity screens for BRAs. The toxicity screen is a tool used to identify COPCs in BRAs and eliminate chemicals that pose little or no risk at a site.

The methods used to derive the direct-contact risk-based action and no-action screening levels (i.e., PRGs) are identified in Appendix B of *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Vol. 1: Human Health* (DOE 2000b).

6.1.6 Evaluation of Uncertainties

Uncertainties are associated with each of the steps of the BRA. Following a general discussion of uncertainties in risk assessment, this section presents the uncertainties that will be addressed in BHHRAs prepared for PGDP and provides a format for summarizing this information (when a qualitative uncertainty analysis or sensitivity analysis is performed). The uncertainty evaluation will be conducted in accordance with *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Vol. 1: Human Health* (DOE 2000b).

The potential effect of the uncertainties on the final risk characterization must be considered when interpreting the results of the risk characterization, because the uncertainties directly affect the final risk estimates. The types of uncertainties that must be considered can be divided into four broad categories. These are uncertainties associated with data and data evaluation (i.e., identification of COPCs), exposure assessment, toxicity assessment, and risk characterization. Specific uncertainties under each of these broad categories that will be addressed in the BHHRAs completed for PGDP are listed in the fo11owing material.

The exact method that will be used to present the uncertainty analysis in all BRAs cannot be included here. This is due, in large part, to the fact that the rigor of the uncertainty analysis will depend upon the unit or area under investigation, the decisions that must be made for the unit or area, and the uncertainties affecting the risk estimates. At minimum, all BRAs will contain a qualitative uncertainty analysis that will include a quantitative sensitivity analysis of salient uncertainties. In the qualitative uncertainty analysis, the magnitude of the uncertainty on the risk characterization will be categorized as small, moderate, or large. Uncertainties categorized as small will be those that should not cause the risk estimates to vary by more than one order of magnitude; uncertainties categorized as moderate will be those that may cause the risk estimates to vary by between one and two orders of magnitude; and, uncertainties categorized as large will be those that may cause the risk estimates to vary by more than two orders of magnitude.

In the qualitative uncertainty analysis, it will be noted that the uncertainties listed and evaluated are neither independent, nor mutually exclusive; therefore, it will be concluded that the total effect of all uncertainties upon the risk estimates is not the sum of the estimated effects of each uncertainty evaluated.

6.1.7 Ecological Assessment Methods

The SERA will quantitatively evaluate potential ecological risks using the methods presented in Vol. 2 of the PGDP Risk Methods Document (DOE 2000d). At minimum, this will include the following items:

- Identification of receptors that may be impacted by contaminants migrating from source areas;
- Discussion of the effects identified contamination may have on receptor populations;
- Summary of the threatened and endangered species known to be present at, or near, PGDP and the potential impacts upon them; and
- Comparison of medium-specific analyte concentrations and activities found at the site with ecological toxicity benchmarks.

The SERA may include additional steps of the baseline ecological risk assessment process outlined in DOE 2000d, as appropriate. The level of effort for these additional steps will be dependent on the ecological information available from historical environmental monitoring activities at PGDP and on the need for derivation of cleanup criteria to be used for the protection of ecological receptors. No specific sampling has been identified to supplement ecological risk assessment process as part of this work plan.

6.2 PRELIMINARY DATA EVALUATION

The historical data evaluation is presented in Chapter 5 of this document. The historical data set was used to compile various risk screening tables required by the methods document for scoping activities. This information is provided in Appendix E of this document.

6.2.1 Characterization and Inventory of Wastes

Information concerning the characterization of these SWMUs is summarized in Chapter 5 of this document.

6.2.2 Information Status of Key Assessment Factors

Transport modeling results contained in previous investigations and risk assessments were examined to determine the types of models that have been completed previously and the results of those modeling activities. All reports considered were from work completed between 1990 and 2004.

As part of this summary, previously completed transport models were categorized into one of the four modeling tiers described in Table 3.2 in the Methods Document (DOE 2000b). These tiers and their descriptions are as follows:

- Tier 1: Results are derived using simple comparisons between sampling results and soil screening levels for groundwater protection. No source-term calculations are performed. Results are used for scoping investigation activities. The point of exposure considered is at the source unit.

- Tier 2: Results are derived using analytical models such as the Multimedia Environmental Pollutant Assessment System (MEPAS), Residual Radioactive Materials (RESRAD), SESOIL, and AT123D. Source-terms are very conservatively derived by assuming that the source-term volume consists of all areas with a detected result, and that the source-term concentration is equal to the maximum detected concentration over all samples. Results are used to determine if a response action should be considered for the source. The point of exposure considered is at the source unit.

- Tier 3: Results are derived using analytical models such as MEPAS, RESRAD, SESOIL, and AT123D. Source-terms are less conservatively derived than under Tier 2 by using three-dimensional plots and/or computer programs that can perform geospatial modeling (e.g., SADA). The source concentration is assumed to be the average concentration over all detected concentrations within the source volume. Results are used in decision documents to select among possible response actions and to derive cleanup levels. The points of exposure considered are at the source unit and at downgradient points (e.g., the fence line, property boundary, and either Little Bayou Creek or the Ohio River).

- Tier 4: Results are derived using numerical models, such as SADA and MODFLOW T. Similar to Tier 3, source-terms are derived using three-dimensional plots and/or computer programs that can perform geospatial modeling. The source concentration is assumed to be the average concentration over all detected concentrations within the source volume. Results are used in decision documents to design a selected response action, such as in refining cleanup levels and selecting monitoring points. The points of exposure considered are at the source unit and at downgradient points (e.g., the fence line, property boundary, and either Little Bayou Creek or the Ohio River).

Generally, all modeling that has been performed for the burial grounds falls within Tier 2; however, in most cases, modeling to downgradient points of exposure (i.e., the fence line and/or property boundary) was included. Modeling to the downgradient points is similar to the Tier 3 requirement. No modeling to Little Bayou Creek or the Ohio River has been completed for the burial grounds.

Below is a summary of the modeling performed for each burial ground. No modeling has been performed for SWMU 145. These summaries are taken from the results presented in Table 6.2. All risk and hazard estimates presented are for hypothetical residential use of groundwater drawn from the RGA.

SWMU 2 is thought to contribute contaminants to the groundwater and is the most modeled of the burial grounds; however, no modeling has extended to Tier 3. Tier 2 modeling results, which have included modeling to points of exposure at the fence line and property boundary, have concluded that this unit is a contributor of TCE and other VOCs to groundwater. In addition, this unit may be a contributor of ^{99}Tc, but the risks due to ^{99}Tc levels are two orders of magnitude less (i.e., equal to 3E-05) than those from solvents (5E-03). This unit probably is not a contributor of metals to groundwater, and an extensive analysis in *Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management 2 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1549&D1, (DOE 1997b), determined that the uranium metal present in the burial ground is unlikely to contribute to groundwater contamination.

SWMU 3 may contribute contaminants to the groundwater; however, no modeling has extended to Tier 3. Tier 2 modeling results, which have modeled to a point of exposure at the property boundary, have concluded that this unit is a minor contributor of ^{99}Tc to groundwater (Risk = 7E-06). Naphthalene has also been identified as a COC (for hazard), but this result is suspect due to conservative source-term development. This unit has not been shown to be a contributor of metals to groundwater.

SWMU 4 may contribute contaminants to the groundwater; however, no modeling has extended to Tier 3. Risk over 1 and hazard over 2,000,000 at a point of exposure at the property boundary have been calculated for this unit. COCs include VOCs [TCE; 1,1-dichloroethene (DCE); vinyl chloride; 1,2-DCE; carbon tetrachloride, and chloroform], metals (As, Co, Cu, Fe, and Mn), and radionuclides (^{137}Np, ^{239}Pu, ^{99}Tc, ^{234}U, ^{235}U, and ^{238}U).

SWMU 5 may contribute to the groundwater; however, no modeling has extended to Tier 3. COCs for risk identified are 1,1-DCE and ^{99}Tc, and COCs for hazard identified are naphthalene, Mn, and Fe. Although risks (5E-05) and hazard (100) have been derived, these results are highly uncertain due to the conservative source-term used in the modeling.

SWMU 6 may contribute contaminants to the groundwater; however, no modeling has extended to Tier 3. Although risk from ^{99}Tc (3E-05) and hazard from iron (20) have been derived, these results are highly uncertain due to the conservative source-term used in the modeling.

SWMU 7 may contribute contaminants to the groundwater; however, Tiers 2 and 3 modeling results indicate that the contamination contributed is probably not significant. While early Tier 2 modeling identified SWMU 7 as a potential source of ^{99}Tc and vinyl chloride, later Tier 3 modeling determined that the level of ^{99}Tc that might reach a receptor at the fence line or property boundary (maximum of 63 and 11 pCi/L) is well below the MCL (900 pCi/L). Later Tier 2 modeling (i.e., that from the site-wide risk model) did identify additional COCs; however, this result is highly uncertain given the conservative source-term used.

Table 6.2 Summary of Previous Modeling Performed for Burial Grounds at PGDP

Unit	Tier/Model Used	Report	Fence line		Property boundary		River/Little Bayou Creek seeps	
			Total risk/hazard	COCs	Total risk/hazard	COCs	Total risk/hazard	COCs
SWMU 2	Tier 1—None	Results of the Public Health and Ecological Assessment, Phase II, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, KY/SUB/13B-97777C P-03/1991/1, December 1991	Not calculated; qualitative determination	TCE, ^{99}Tc, Be, Cr, Pb	Not calculated	NA	Not calculated	NA
	Tier 1—None	Solid Waste Landfill Subsurface Investigation Report, KY/ERWM-12, February 1994.	Not calculated; qualitative determination	^{99}Tc, U, metals	Not calculated	NA	Not calculated	NA
	Tier 2—MEPAS	Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-1549&D1, February 1997b	VOCs Risk = 3E-05 Hazard = <1 Dose = NA Based on predicted maximum concentration at fence at 35 years from present	TCE	Risk = 2E-05 Hazard = <1 Dose = NA Based on predicted maximum concentration at fence 35 years from present	TCE	Not calculated	NA
			Metals Risk = 1E-05 Hazard = <1 Dose = NA Based on predicted maximum concentration at fence at 1505 years from present	Arsenic	Risk = 1E-05 Hazard = <1 Dose = NA Based on predicted maximum concentration at boundary at more than 1000 years from present	Arsenic	Not calculated	NA
	Tier 2—SESOIL/ AT123D	Site-Wide Risk Model and Environmental Baseline for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-2104&D0, September 2003	Not calculated	NA	Risk = 6E-03 Hazard = 1000 Dose = <1 mrem/year	Risk: TCE, vinyl chloride, ^{99}Tc Hazard: cis-1,2-DCE; TCE	Not calculated	NA
SWMU 3	Tier 1—None	Results of the Public Health and Ecological Assessment, Phase II, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, KY/SUB/ 13B-97777C P-03/1991 /1, December 1991	Not calculated; qualitative determination	TCE, ^{99}Tc, Be, Cr, Pb	Not calculated	NA	Not calculated	NA

Table 6.2 Summary of Previous Modeling Performed for Burial Grounds at PGDP (continued)

Unit	Tier/Model Used	Report	Fence line		Property boundary		River/Little Bayou Creek seeps	
			Total risk/hazard	COCs	Total risk/hazard	COCs	Total risk/hazard	COCs
SWMU 3	Tier 2—SESOIL/AT123D	Site-Wide Risk Model and Environmental Baseline for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-2104&D0, September 2003	Not calculated	NA	Risk = 7E-06 Hazard = 2 Dose = <1 mrem/year	Risk: ^{99}Tc Hazard: naphthalene	Not calculated	NA
SWMU 4	Tier 2—MEPAS	Remedial Investigation Report for Waste Area Grouping 3 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-1895&D1, September 2000	TCE and solvents Risk = 6E-02 Hazard = 2000 (Assumed 100 years from present)	Risk: 1,1-DCE; TCE; vinyl chloride; carbon tetrachloride Hazard: 1,1-DCE; TCE	Not calculated; however, a comparison of concentrations indicates that risks and hazards would be about one order of magnitude less.	Can be assumed the same as fence line COCs for work plan development	Not calculated	NA
			Metals and radionuclides Risk = 6E-03 Hazard = 400 (Assumed at >1000 years from present)	Risk: As, ^{137}Np, ^{239}Pu, ^{99}Tc, ^{234}U, ^{235}U, ^{238}U Hazard: As, Co, Cu, Fe, Mn				
			Dose = Not calculated	NA				
	Tier 2—SESOIL/AT123D	Site-Wide Risk Model and Environmental Baseline for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-2104&D0, September 2003	Not calculated	NA	Risk = >1 Hazard = 2,000,000 Dose = 2 mrem/year	Risk: carbon tetrachloride; chloroform; 1,1-DCE; TCE; vinyl chloride; ^{99}Tc Hazard: carbon tetrachloride; chloroform; cis-1,2-DCE; trans-1,2-DCE; 1,1-DCE; TCE; vinyl chloride Dose: ^{99}Tc	Not calculated	NA

Table 6.2 Summary of Previous Modeling Performed for Burial Grounds at PGDP (continued)

Unit	Tier/Model Used	Report	Fence line		Property boundary		River/Little Bayou Creek seeps	
			Total risk/hazard	COCs	Total risk/hazard	COCs	Total risk/hazard	COCs
SWMU 5	Tier 2—MEPAS	Remedial Investigation Report for Waste Area Grouping 3 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-1895&D1, September 2000	TCE and solvents Risk = <1E-06 Hazard = <1	Risk: none Hazard: none	Not calculated; however, a comparison of concentrations indicates that risks and hazards would be about one order of magnitude less.	Can be assumed the same as fence line COCs for work plan development	Not calculated	NA
			Metals and radionuclides Risk = <1E-06 Hazard = 100 (Assumed at >1000 years from present)	Risk: none Hazard: Fe, Mn				
			Dose = Not calculated	NA				
	Tier 2—SESOIL/AT123D	Site-Wide Risk Model and Environmental Baseline for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-2104&D0. September 2003	Not calculated	NA	Risk = 5E-03 Hazard = 100 Dose = <1 mrem/year	Risk: 1,1-DCE and ^{99}Tc Hazard: naphthalene Dose: None	Not calculated	NA
SWMU 6	Tier 2—MEPAS	Remedial Investigation Report for Waste Area Grouping 3 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-1895&D1, September 2000	TCE and solvents Risk = <1E-06 Hazard = <1	Risk: none Hazard: none	Not calculated; however, a comparison of concentrations indicates that risks and hazards would be about one order of magnitude less.	Can be assumed the same as fence line COCs for work plan development	Not calculated	NA
			Metals and radionuclides Risk = <1E-06 Hazard = 20 (Assumed at >1000 years from present)	Risk: none Hazard: Fe				
			Dose = Not calculated	NA				
	Tier 2—SESOIL/AT123D	Site-Wide Risk Model and Environmental Baseline for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-2104&D0. September 2003	Not calculated	NA	Risk = 3E-05 Hazard = <1 Dose = <1 mrem/year	Risk: ^{99}Tc Hazard: none Dose: none	Not calculated	NA
SWMU 7	Tier 1—None	Results of the Public Health and Ecological Assessment, Phase II, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, KY/SUB/13B-97777C P-03/1991/1	Not calculated; qualitative determination	TCE; 1,2-DCE; vinyl chloride; ^{99}Tc; As; Cr; Ni	Not calculated	NA	Not calculated	NA

Table 6.2 Summary of Previous Modeling Performed for Burial Grounds at PGDP (continued)

Unit	Tier/Model Used	Report	Fence line		Property boundary		River/Little Bayou Creek seeps	
			Total risk/hazard	COCs	Total risk/hazard	COCs	Total risk/hazard	COCs
SWMU 7	Tier 2—SESOIL/AT123D	Remedial Investigation Report for Solid Waste Management Units 7 and 30 of Waste Area Grouping 22 at Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-1604&D2, January 1998	Not calculated	NA	Risk = 2E-04 Hazard = <1 Dose = Not calculated (Results are for sources at both SWMUs 7 and 30 and are for 100 years from present.)	Risk: vinyl chloride, ^{99}Tc Hazard: none Dose: NA	Not calculated	NA
	Tier 3—SESOIL/AT123D	Technetium-99 Transport Modeling Results for Sources at SWMUs 7 and 30 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, KY/EM-266, March 1998	Risk = Not calculated Hazard = NA Dose = Not calculated [Results are maximum contribution from the incinerator area (Area Z) in SWMU 7]	Maximum concentration of ^{99}Tc was 63 pCi/L at 20 years from present	Risk = Not calculated Hazard = NA Dose = Not calculated [Results are maximum from the incinerator area (Area Z) in SWMU 7]	Maximum concentration of ^{99}Tc was 11 pCi/L at 25 years from present	Not calculated	NA
	Tier 2—SESOIL/AT123D	Site-Wide Risk Model and Environmental Baseline for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-2104&D0, September 2003	Not calculated	NA	Risk = 8E-04 Hazard = 30 Dose = 11 mrem/year	Risk: benzene, chloroform, ethylbenzene, ^{99}Tc Hazard: Cu, benzene, naphthalene Dose: ^{99}Tc	Not calculated	NA
SWMU 30	Tier 1—None	Results of the Public Health and Ecological Assessment, Phase II, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, KY/SUB/13B-97777C P-03/1991/1	Not calculated; qualitative determination	TCE; 1,2-DCE; vinyl chloride; ^{99}Tc; As; Cr; Ni	Not calculated	NA	Not calculated	NA
	Tier 2—SESOIL/AT123D	Remedial Investigation Report for Solid Waste Management Units 7 and 30 of Waste Area Grouping 22 at Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-1604&D2, January 1998	Not calculated	NA	Risk = 2E-04 Hazard = <1 Dose = Not calculated (Results are for sources at both SWMUs 7 and 30 and are for 100 years from present.)	Risk: vinyl chloride, ^{99}Tc Hazard: none Dose: NA	Not calculated	NA

Table 6.2 Summary of Previous Modeling Performed for Burial Grounds at PGDP (continued)

Unit	Tier/Model Used	Report	Fence line		Property boundary		River/Little Bayou Creek seeps	
			Total risk/hazard	COCs	Total risk/hazard	COCs	Total risk/hazard	COCs
SWMU 30	Tier 3—SESOIL/AT123D	Technetium-99 Transport Modeling Results for Sources at SWMUs 7 and 30 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, KY/EM-266, March 1998	Risk = Not calculated Hazard = NA Dose = Not calculated (Results are maximum contribution from Pits B/C in SWMU 30.)	Maximum concentration of ^{99}Tc was 122 pCi/L at 20 years from present	Risk = Not calculated Hazard = NA Dose = Not calculated (Results are maximum contribution from Pits B/C in SWMU 30.)	Maximum concentration of ^{99}Tc was 21 pCi/L at 25 years from present	Not calculated	NA
	Tier 2—SESOIL/AT123D	Site-Wide Risk Model and Environmental Baseline for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-2104&D0. September 2003	Not calculated	NA	Risk = 3E-04 Hazard = 8 Dose = 5 mrem/year	Risk: ^{99}Tc Hazard: naphthalene Dose: ^{99}Tc	Not calculated	NA

COC = Chemical of concern
DCE = Dichloroethene
MEPAS = Multimedia Environmental Pollutant Assessment System
mrem = millirem
NA = Not applicable
SESOIL = Seasonal Soil Compartment Model
SWMU = Solid waste management unit
TCE = Trichloroethene
VOC = Volatile organic compound

SWMU 30 may contribute contaminants to the groundwater; however, Tiers 2 and 3 modeling results indicate that the contamination contributed is probably not significant. While early Tier 2 modeling identified SWMU 7 as a potential source of ^{99}Tc and vinyl chloride; later Tier 3 modeling determined that the level of ^{99}Tc that might reach a receptor at the fence line or property boundary (maximum of 122 and 21 pCi/L) is well below the MCL (900 pCi/L). Later Tier 2 modeling (i.e., that from the site-wide risk model) did identify ^{99}Tc as an important COC; however, this result is highly uncertain given the conservative source-term used.

Considering the conservative nature of the modeling performed to date and modeling uncertainties, it is likely that only SWMUs 2 and 4 are contributing contamination to groundwater at the PGDP that potentially could adversely affect an off-site resident. SWMU 2 may be a contributor of VOCs and possibly ^{99}Tc to groundwater, and SWMU 4 may be a contributor of VOCs, metals, and radionuclides. While modeling results for SWMUs 3, 5, 6, and 7 and 30 have identified some COCs, it is likely that source-term refinement under Tier 3 modeling would reduce risks and hazards to off-site receptors to levels below those of concern.

No modeling to points of exposure at the Ohio River and Little Bayou Creek has been completed for the burial grounds. However, modeling results for other units to these hypothetical potential points of exposure [e.g., in *Feasibility Study for the Groundwater Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1857&D2, (DOE 2001b); and *Risk and Performance Evaluation of the C-746-U Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-2041&D2/R1] (DOE 2001c) and sampling results from seeps along Little Bayou Creek indicate that modeled or actual contaminant concentrations at these points of exposure are likely to be one or two orders of magnitude less than those derived or measured at the property boundary point of exposure.

6.2.3 Release Potential from Contaminant Sources

The conceptual site model presented in Figure 6.1 identifies the probable and potential contaminant migration and exposure pathways at BGOU SWMUs. From the source, two probable pathways are identified: (1) a probable pathway to the adjacent subsurface soils, and (2) a probable pathway to groundwater due to leaching and dissolution of contaminants. These probable pathways will be the focus of the investigation activities. Consistent with DOE strategy, TCE is considered a potential source beneath the buried waste. Potential exposure to contamination at BGOU SWMUs via air currently is limited, since the areas are covered with caps and/or vegetation. Potential exposure of TCE via vapor intrusion will be evaluated in the BHHRA. The modeling will be completed using the Johnson and Ettinger vapor intrusion model, advanced groundwater version.

Figure 6.2 shows an illustration of the typical conceptual model for these burial grounds.

The following material, adapted from the PGDP Risk Methods document (DOE 2000b), describes how fate and transport modeling will be used to consider future conditions. As shown in Table 6.3, modeling will follow a tiered process. In this process, lower tiers (i.e., Tiers 1 and 2 in Table 6.3) are completed using simple screens and analytical models, and results are used to identify conservatively COPCs. Higher tiers, (i.e., Tiers 3 and 4 in Table 6.3) are completed for COPCs identified in lower tiers using more sophisiticated analytical and numerical models, and results are used to identify COCs that are the focus of later decision documents.

Table 6.3 Modeling Matrix for Groundwater[a]

	Values for Soil to Protect Groundwater	Model	Point of Exposure	Notes
INVESTIGATION DOCUMENTS	Tier 1 Initial analysis used to identify COPCs that might migrate from source areas and require further fate and transport analysis.	Concentrations in source term are the maximum detected concentrations of contaminants in the source. Contaminant concentrations compared to site screening levels and Groundwater Protection values in Appendix A of the PGDP Methods Document.	At source unit	Use dilution/attenuation factor (DAF) of 1 for site screening levels unless site-specific values are available. Groundwater Protection value based on residential use and targets of 1E-6, 0.1, and 1 for risk, hazard, and dose, respectively. If site-specific DAF values are used, then the Groundwater Protection value should be justified. The depth to groundwater will be considered in the calculation.
	Tier 2 Analysis is used to refine the list of COPCs that might migrate from source areas. Depending on the DQOs for the project, additional fate and transport analysis of selected COPCs might be completed.	Concentrations in source term for all contaminants are the lesser of the maximum and UCL95 concentration of the appropriate distribution. Fate and transport modeling completed using SESOIL and/or RESRAD.	At source unit	Includes source delimitation. The analysis will recognize SESOIL limitations when modeling inorganic COPCs-refine K_ds.
DECISION DOCUMENTS	Tier 3 Analysis is used for COCs identified from Tier 2 modeling. Includes consideration of COC concentrations at downgradient locations. The results of this analysis may be used to develop clean-up levels for some COCs.	Source term developed using SADA. Fate and transport completed using SESOIL and RESRAD with AT123D.	At source unit and at down-gradient exposure points. Exposure points are at the plant boundary, the property boundary, Little Bayou Creek, and the Ohio River.	Uses source delimitation and refined K_ds from previous tiers. Contaminant migration paths will be derived using the site-wide groundwater model. On the Terrace (southern portion of PGDP) different points of exposure will apply and be determined using the site-wide groundwater model.
	Tier 4 Analysis is used for the COCs presenting the greatest risk at downgradient exposure points. The results of this analysis may be used to develop clean-up levels for some COCs.	Source modeling and MODFLOW T	Down-gradient points Exposure points are at the plant boundary, the property boundary, Little Bayou Creek, and the Ohio River.	To be used to refine clean-up goals (if needed). On the Terrace (southern portion of PGDP) different points of exposure will apply. On the Terrace (southern portion of PGDP) different points of exposure will apply and be determined using the site-wide groundwater model.

[a] Adapted from Table 3.2 of the PGDP Methods Document (DOE/OR/07-1506&D2).

6.3 SAMPLING STRATEGY

This BGOU RI/FS Work Plan defines the additional sampling necessary to obtain sufficient data for completing the BGOU risk assessment and initiating the FS. Many of these SWMUs have been previously investigated during an RI. The strategy for this work plan is to identify data gaps and complete characterization of the nature and extent of contamination for each SWMU.

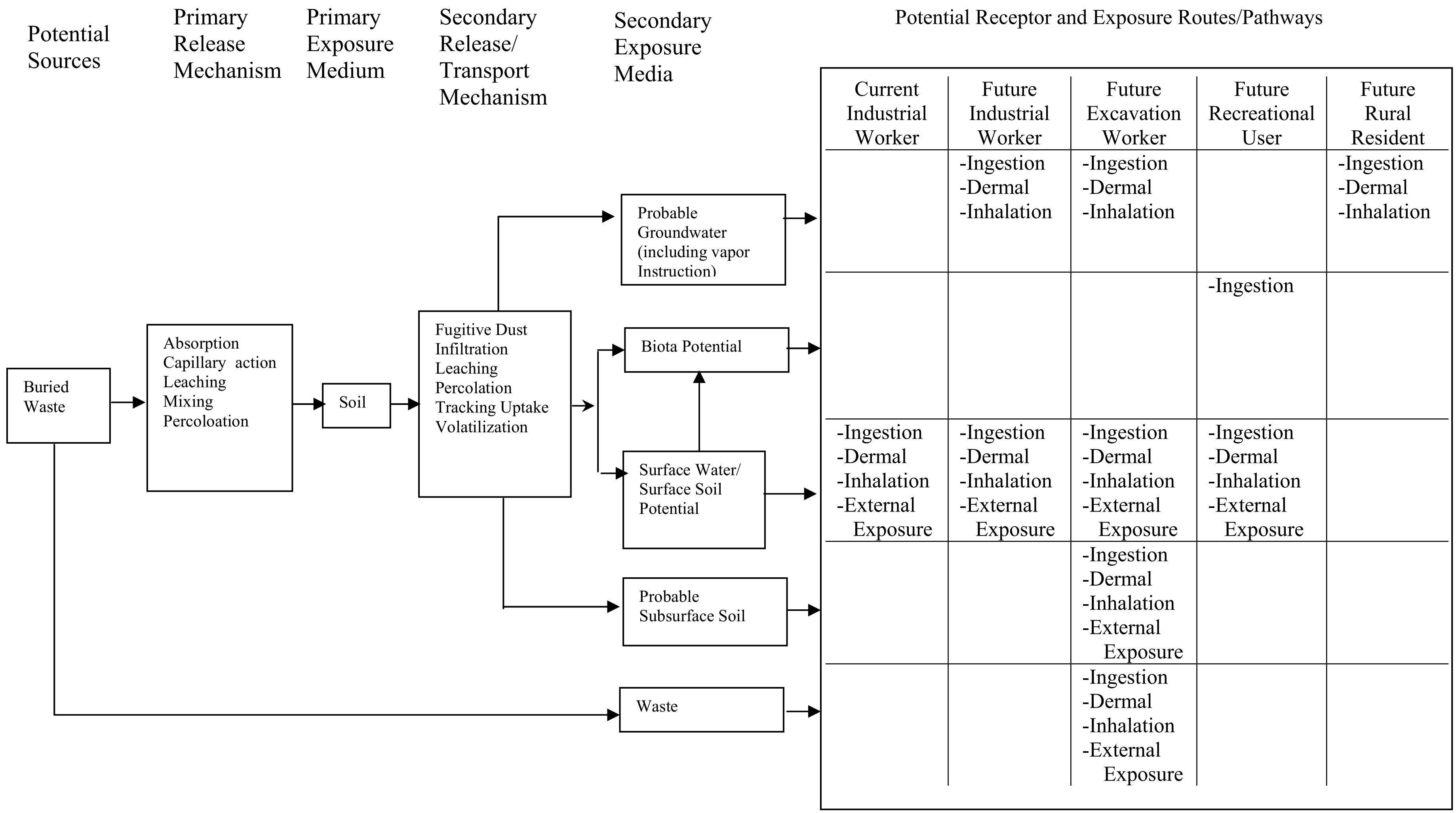
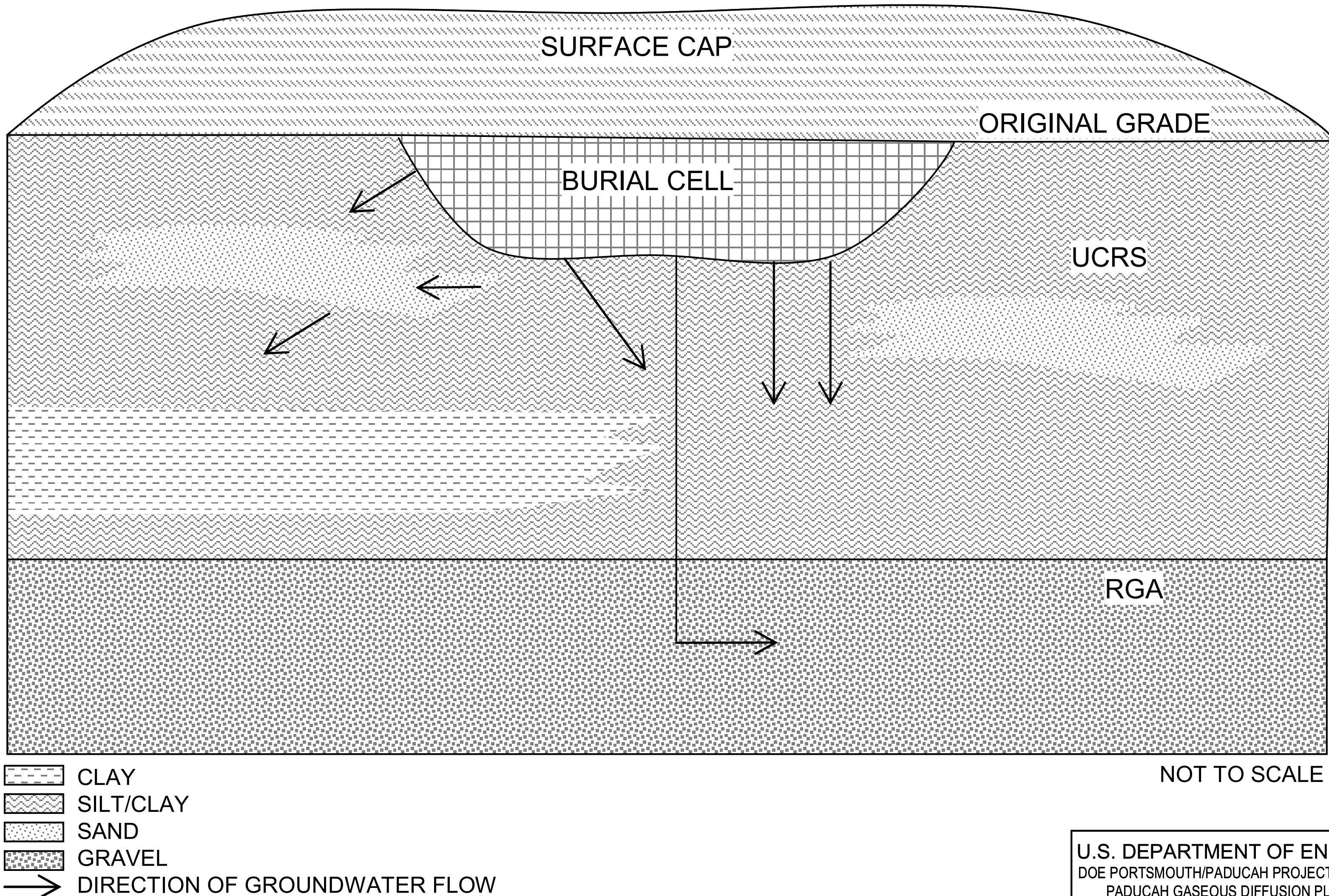


Figure 6.1. BGOU SWMUs Conceptual Model



U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

PADUCAH Remediation Services
A Portage Shaw Joint Venture Company

Figure 6.2. BGOU Conceptual Model Illustration

7. TREATABILITY STUDIES

Treatability studies involve testing technologies to assess their performance on specific wastes or media. This section includes a discussion of the treatability study process. No treatability studies have been identified at this time for the BGOU; however, as the RI/FS is implemented and alternatives are evaluated, additional studies may be identified.

7.1 IDENTIFICATION OF TREATABILITY STUDIES NEEDED

Treatability studies involve testing one or more technologies to gain qualitative or quantitative information to assess their performance on specific wastes or media at the site. Treatability studies are conducted primarily to do the following:

- Provide sufficient data to allow treatment alternatives to be fully developed and evaluated during the detailed analysis and to support the FS and remedial design of a selected alternative,
- Reduce cost and performance uncertainties for treatment alternatives to acceptable levels so that a remedy can be selected,
- Support remedy screening,
- Support remedy selection, and
- Support remedy implementation.

Treatability studies are conducted, as appropriate, to collect data on technologies identified during the alternative development process, thus, providing additional information for their evaluation. The RI/FS contractor and DOE's project manager must review the existing site data and available information on technologies to determine if treatability investigations are needed.

The need for treatability testing should be identified as early in the RI/FS process as possible. A decision to conduct treatability testing may be made during project scoping if information indicates that such testing is desirable. However, the decision to conduct these activities must be made by weighing the cost and time required to complete the investigation against the potential value of the information in resolving uncertainties associated with selection of a remedial action. In some situations, a specific technology that appears to offer a substantial savings in costs or significantly greater performance capabilities may not be identified until the later phases of the RI/FS. Under such circumstances, it may be advantageous to postpone completion of the RI/FS until treatability studies can be completed. Appropriate project personnel will need to make such decisions on a case-by-case basis. In other situations, treatability investigations may be postponed until after the remedial design phase.

The design process for treatability studies is shown, conceptually, in Figure 7.1 and consists of the following four steps:

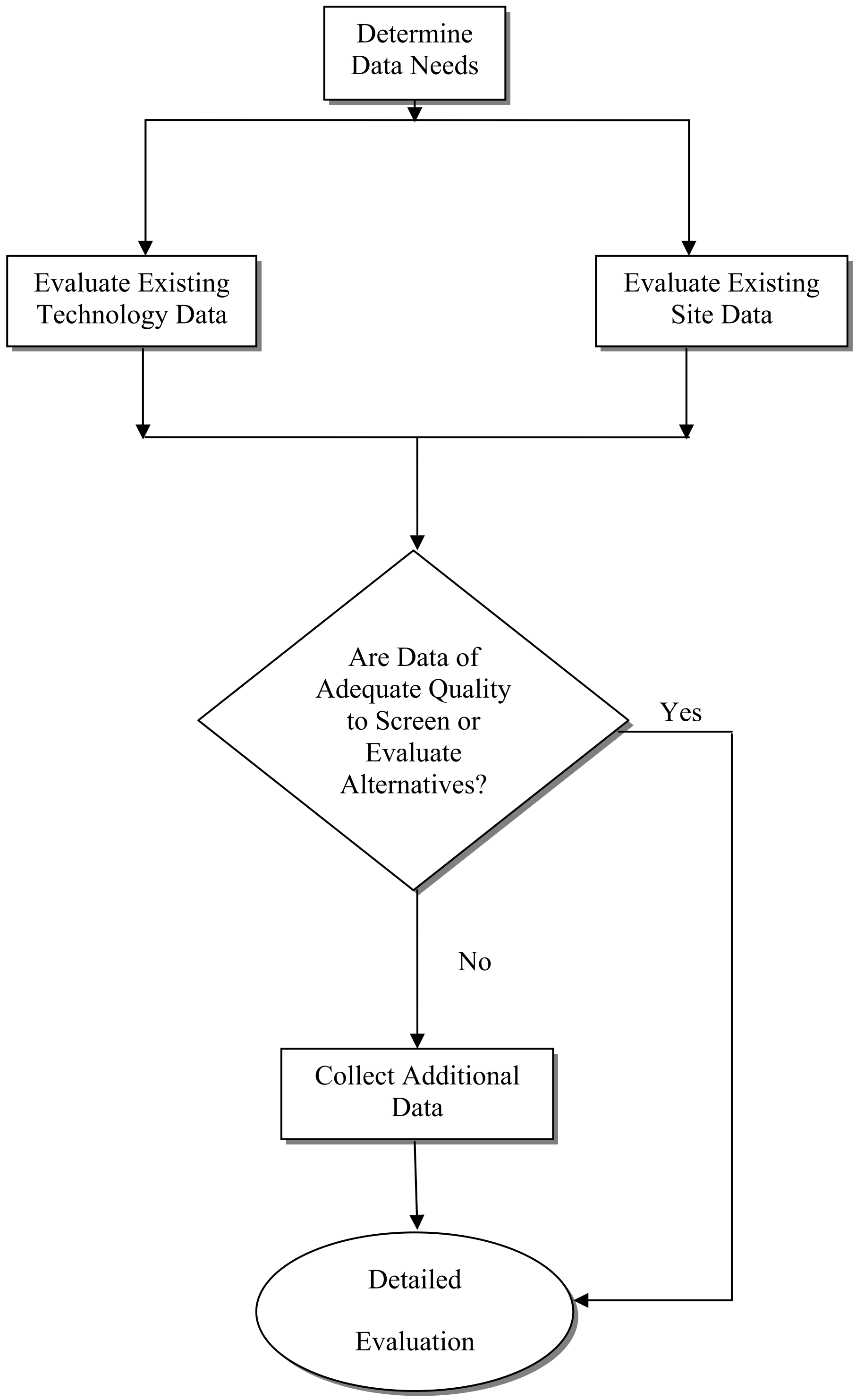


Figure 7.1. Flowchart for Treatability Study

(1) Determination of data needs;

(2) Review of existing data on the site and available literature on technologies to determine if existing data is sufficient for the evaluation of alternatives;

(3) Performance of treatability tests, as appropriate, to determine performance, operating parameters, and relative costs of potential remedial technologies; and

(4) Evaluation of the treatability data to ensure that DQOs are met.

Certain technologies have been demonstrated such that site-specific information collected during the site characterization is adequate to evaluate and determine the cost of these technologies without conducting treatability testing. Situations where treatability testing may not be necessary include the following:

- A developed technology has been well proven in similar applications;
- A technology previously has been used extensively to treat well-documented waste materials (e.g., stripping or carbon adsorption for groundwater containing organic compounds for which treatment previously has proven effective); or
- Relatively low removal efficiencies are required (e.g., 50% to 90%), and data are already available.

Frequently, technologies have not been demonstrated sufficiently or characterization of the waste alone is insufficient to predict treatment performance or to estimate the size and cost of appropriate treatment units. Furthermore, some treatment processes are not understood sufficiently for performance to be predicted, even with a complete characterization of the wastes. For example, often it is difficult to predict biological toxicity in a biological treatment plant without pilot tests. When treatment performance is difficult to predict, an actual testing of the process may be the only means of obtaining the necessary data. In fact, in some situations, it may be more cost-effective to test a process on the actual waste than it would be to characterize the waste in sufficient detail to predict performance.

7.2 DESCRIPTION OF STUDY TO BE PERFORMED

Treatability testing performed during an RI/FS is used to evaluate technologies, including evaluation of performance, determination of process-sizing, and estimation of costs, in sufficient detail to support the remedy-selection process. Treatability testing can be performed using bench-scale or pilot-scale techniques that involve implementing and evaluating the performance of a small-scale system in order to determine the potential benefits in construction and operation of a large-scale system. Treatability testing in the RI/FS is not intended solely to develop detailed design or operating parameters that are more appropriately developed during the remedial design phase.

In general, treatability studies will include the following steps:

(1) Preparation of a work plan (or modification of the existing work plan) for bench or pilot studies;

(2) Performance of field sampling, bench testing, and/or pilot testing;

(3) Evaluation of data from field studies, bench testing, and/or pilot testing; and

(4) Preparation of a report documenting the test results.

7.3 ADDITIONAL SITE DATA NEEDED FOR STUDY OR EVALUATION

Before evaluation for remedy selection in the FS, sufficient data must be available to allow treatment alternatives to be fully developed and evaluated. Additional data are needed to do the following:

- Determine whether the performance of the technologies under consideration has been documented sufficiently on similar wastes, considering the scale (e.g., bench, pilot, or full) and the number of times that the technologies have been used;
- Gather information on relative costs, applicability, removal efficiencies, operation and maintenance requirements, and implementability of the candidate technologies;
- Determine site geology and geochemistry;
- Determine whether characterization of the waste is sufficient to predict treatment performance or to estimate size and cost of the appropriate treatment system; and
- Determine power needs and differences in performance among competing manufacturers.

7.4 SCHEDULE FOR SUBMISSION OF ADDITIONAL TREATABILITY STUDY WORK PLANS

Technologies that may be applicable to the BGOU that require treatability studies will be identified as early as possible during the RI/FS process. When possible, treatability studies will be coordinated across the site where unit characteristics appear similar. At any time during the RI/FS process that a treatability study is determined to be necessary, the issue will be discussed with EPA and KDEP.

Based on the information currently available, potential treatability technologies include the following:

- *In situ* stabilization using grouting, freezing, or other related technologies; and
- Thermal heating of soils and groundwater underlying and adjacent to the burial cells (without directly impacting the burial cells).

As the RI/FS process progresses, a determination will be made as to whether the performance of treatability studies is necessary. At this time, there is no need to perform a treatability study based on an evaluation of potential remedial alternatives and sufficient lessons learned and information available from other sites that have implemented remedial actions for burial grounds. If the performance of treatability studies is required, a treatability study work plan will be submitted. Treatability studies generally require 6 to 24 months to complete. If the performance of treatability studies is deemed necessary, DOE will notify EPA and KDEP of the study schedule.

8. ALTERNATIVES DEVELOPMENT

This section explains the process that will be used to develop and evaluate alternatives during the BGOU FS. Topics addressed in this section of the work plan include the following:

- A description of the general approach to investigating and evaluating potential remedies;
- The overall objective of the study, a discussion of preliminary identification, general response actions, and remedial technologies;
- A remedial alternatives development and screening; and
- A detailed analysis of remedial alternatives.

A discussion of the format for the FS and the schedule, or timing for conducting the study also is provided.

8.1 DESCRIPTION OF THE GENERAL APPROACH TO INVESTIGATING AND EVALUATING POTENTIAL REMEDIES

Under CERCLA, an FS is completed in conjunction with an RI. The process for conducting a CERCLA FS begins with scoping the RI/FS. Development and screening of alternatives are performed after the site characterization or RI. Treatability studies may be performed, if necessary, to evaluate adequately the alternative's effect on particular site-specific waste streams. Then, before the selection of a remedy, the alternatives undergo a detailed evaluation using the nine evaluation criteria outlined in 40 Code of Federal Regulations (CFR) 300.430(e)(9)(iii).

The draft generic baseline schedule includes an activity titled, "Prepare Draft FS Report." Five steps are identified under this report preparation activity: (1) alternatives development, (2) preliminary technology screening, (3) detailed evaluation of alternatives, (4) document consolidation, and (5) issuance of a draft FS report to DOE. The first three steps are intended to parallel the CERCLA FS process, and the last two lead to preparation of an FS report.

8.2 OVERALL OBJECTIVES OF THE FEASIBILITY STUDY

The primary objective of the FS is to ensure that appropriate remedial alternatives are developed and evaluated so that relevant information concerning the remedial action options can be presented to a decision maker and an appropriate remedy can be selected [40 CFR 300.430(e)(1)]. This information must be adequate to ensure that an appropriate remedy can be selected and provide protection of human health and the environment by recycling waste or by eliminating, reducing, or controlling risks.

8.3 PRELIMINARY IDENTIFICATION OF GENERAL RESPONSE ACTIONS AND REMEDIAL TECHNOLOGIES

This section will summarize the identification of potential remedial technologies for the BGOU. Additional technologies will be identified and screened, as necessary, during review of the RI report. In accordance with the requirements of the National Contingency Plan, DOE will consider the following remedial alternatives:

- No action
- Institutional controls
- Containment
- Treatment
- Removal

For each general response action, technology types will be identified. Potentially applicable technologies will be identified by referring to the alternatives evaluation section of the draft *Summary of Alternatives for Remediation of Offsite Contamination at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1991). Additionally, databases, such as the Electronic Encyclopedia of Remedial Action Options and the Vendor Information System for Innovative Treatment Technologies, will be queried to develop additional technologies. Alternatives for remediation will be developed by assembling combinations of technologies and the media to which they would be applied into alternatives that address contamination identified for the BGOU. This process will consist of development of alternatives, screening of alternatives, and detailed analysis of alternatives. Tools, such as the Remedial Action Assessment System, may be used.

8.4 REMEDIAL ALTERNATIVES DEVELOPMENT AND SCREENING

The primary objective of the alternatives development and screening phase is to generate a list of potential remedial alternatives. The alternatives developed are to protect human health and the environment, to identify potentially suitable technologies (including innovative technologies), and to assemble the technologies into alternative remedial actions. These alternative remedial actions then will undergo a detailed analysis during the next phase of the FS.

Consistent with the EPA Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3-01 (EPA 1988), the remedial alternatives development and screening phase will consist of six general steps, which follow:

(1) **Development of remedial action objectives.** COCs, exposure pathways, and RGOs will be taken into account to allow for the development of a range of treatment and containment alternatives.

(2) **Development of general response actions.** Response actions will be identified that satisfy the remedial action objectives for the BGOU sites (e.g., capping, excavation).

(3) **Identification of volume or area.** The volume or area to which general response actions may be applied will be identified.

(4) **Identification and screening of technologies applicable to each general response action.** Those technologies that cannot be technically implemented at the site will be eliminated. Definitions of the general response also will be modified to specify remedial technology types.

(5) **Identification and evaluation with technology process options.** A representative process for each remaining technology type will be selected to represent the technology type for alternative development and evaluation.

(6) **Assembly of the selected representative technologies.** The technologies will be assembled into alternatives that represent a range of remedial options, including treatment and containment.

As required by 40 CFR 300.430(e)(4), a limited number of remedial alternatives will be developed that attain remediation goals within different restoration time periods using one or more different technologies. In addition, one or more innovative technologies will be developed for detailed evaluation, to the extent required by, [40 CFR 300.430(e)(5)]. A no action alternative also will be evaluated [40 CFR 300.430(e)(6)].

The alternatives that are developed will undergo a screening evaluation. As appropriate, and to the extent sufficient information is available, the screening evaluation will consist of an effectiveness assessment, an implementability appraisal, and a cost evaluation [40 CFR 300.430(e)(7)].

The remaining alternatives then will undergo a detailed evaluation [40 CFR 300.430(e)(9)].

8.5 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The detailed analysis of alternatives involves evaluating each of the alternatives remaining after the screening described in Section 2.6.4, using the nine evaluation criteria. The alternatives then are compared. The results of the detailed analysis will allow an appropriate remedy to be selected.

CERCLA requires that nine criteria be used to evaluate the expected performance of remedial actions. The criteria are categorized as threshold, balancing, and modifying criteria. The nine criteria are identified in the following discussion.

8.5.1 Threshold Criteria

According to 40 CFR 300.430(f)(1)(I)(A), these threshold criteria must be met. An alternative must allow for the following in order to be selected as the remedy.

(1) **Overall protection of human health and the environment.** This criterion requires that the alternative adequately protect human health and the environment [40 CFR 300.430(e)(9)(iii)(A)].

(2) **Compliance with ARARs (unless a specific ARAR is waived).** Congress specified in CERCLA §121 that remedial actions for cleanup of hazardous substances must comply with requirements, criteria, standards, or limitations under federal or more stringent state environmental laws that are applicable or relevant and appropriate to the hazardous substances or circumstances at a site [40 CFR 300.430(e)(9)(iii)(B)]. The potential ARARs for the BGOU are presented in Appendix A.

8.5.2 Balancing Criteria

These criteria are considered in determining which alternative best achieves or comes closest to achieving the threshold criteria [40 CFR 300.430(f)(1)(I)(B)]. The balancing criteria evaluate the alternatives in terms of the following five qualities.

(1) **Long-term effectiveness and permanence.** This criterion focuses on the magnitude and nature of the risks associated with untreated waste/treatment residuals. This criterion includes consideration of the adequacy and reliability of any associated engineering controls, such as monitoring and maintenance requirements [40 CFR 300.430(e)(9) (iii)(C)].

(2) **Reduction of contaminant toxicity, mobility, or volume through treatment.** This criterion evaluates the degree to which the alternative employs treatment to reduce the toxicity, mobility, or volume of contamination [40 CFR 300.430(e)(9)(iii)(D)].

(3) **Short-term effectiveness.** This criterion evaluates the effect of implementing the alternative relative to potential risks to the general public, potential threat to workers, and time required until protection is achieved [40 CFR 300.430(e)(9)(iii)(E)].

(4) **Implementability.** This criterion reviews potential difficulties associated with implementing the alternative. These difficulties may involve technical feasibility, administrative feasibility, and availability of services and materials [40 CFR 300.430(e)(9)(iii)(F)].

(5) **Cost.** This criterion weighs the capital cost, annual operation and maintenance, and the combined net present value [40 CFR 300.430(e)(9)(iii)(G)].

8.5.3 Modifying Criteria

These criteria allow for the influences of the community and the state.

(1) **Community acceptance.** This criterion requires the consideration of any formal comments by the community regarding any action to be performed [40 CFR 300.430(e)(9)(iii)(I)].

(2) **State acceptance.** This criterion requires the consideration of any formal comments by the state regarding any action to be performed [40 CFR 300.430(e)(9)(iii)(H)].

A preferred alternative will be identified in accordance with the requirements of RCRA and CERCLA. The selections will be based on analysis of technical, human health, and environmental criteria. The remedy selection process must follow the requirements of 40 CFR 300.430(e), including the proposed plan, community involvement, and preparation of a Record of Decision.

8.5.4 Potential Remedial Actions

Based on the information presented in Chaps. 7 and 8, Tables 8.1 and 8.2 list potential remedial actions, which can be implemented individually or in combination, for the targeted media at these SWMUs. These potential remedial actions are subject to change, which may include the addition or deletion of specific actions as the RCRA/CERCLA process proceeds.

8.6 FORMAT FOR THE FEASIBILITY STUDY REPORT

Appendix D contains the draft "Integrated FS/CMS Report" outline, as specified in Appendix D of the FFA. This outline will be the basis for the BGOU FS report, the text of which will incorporate NEPA values, consistent with the DOE 1994 Secretarial Policy on NEPA.

Table 8.1 Potential Remedial Actions for Primary Sources (Waste and Vadose Soils)

Soil	
Institutional Controls	• Access controls • Land-use restrictions • Environmental media monitoring
Containment	• Low-permeability capping • Constructed barriers • Dust and vapor suppression • Erosion control • Retro-fitted liners • Surface water control
Recovery or Removal	• Excavation/storage • Excavation/disposal
Treatment	• *In situ* grouting • Freezing

Table 8.2 Potential Remedial Actions for Secondary Sources (DNAPL)

Groundwater	
Institutional Controls	• Access controls • Land-use restrictions • Environmental media monitoring
Containment	• Constructed barriers • Hydraulic containment • Retro-fitted liners • Subsurface drainage
Recovery or Removal	• Extraction/storage • Extraction /disposal
Ex Situ Treatment	• Coagulation/flocculation • Freeze crystallization • Gravity separation • Media filtration • Membrane separation • Neutralization
In Situ Treatment	• *In situ* neutralization • Reactive walls • Phytoremediation

8.7 SCHEDULE/TIMING FOR CONDUCTING THE STUDY

Feasibility studies will be conducted after the fieldwork is completed, currently scheduled for 2006 (Figure 2.3).

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9. FIELD SAMPLING PLAN

The primary focus of the BGOU RI/FS will be to collect field and analytical data necessary to determine the nature and extent of any soil and groundwater contamination originating from, and immediately under, the burial cells; support the completion of a BHHRA and SERA; and evaluate appropriate remedial alternatives (if necessary) at each of the SWMUs. Figure 1.1 shows the location of the BGOU SWMUs relative to the various TCE plumes.

The existing data and identified data gaps are delineated in Section 5 of this work plan. The identified data gaps for each SWMU have been carried forward in this section and serve as the basis for the proposed investigative activities. For most of the SWMUs the primary data gap is the presence and extent of soil and groundwater contamination, if any, directly below the burial cells. To close this data gap, the sampling strategy is focused on collecting soil and groundwater samples from angle borings drilled adjacent to the burial cells (without penetrating the cells) and terminating under the burials cells and above the RGA.

The existing data for SWMU 4 was evaluated to be sufficient to evaluate nature and extent of contamination and provide data from under burial cells; therefore no additional samples are proposed for this SWMU. Borings were collected from under burial cells for SWMUs 5 and 6 in a previous investigation; however, not all cells were evaluated. For SWMU 5 additional borings will be collected from cells not previously targeted. For SWMU 6, physical constraints limited access to the area. During the previous investigation. Equipment has been removed from the area and it now is possible to collect samples and evaluate those cells.

Sampling activities will focus on the soils and groundwater beneath the burial pits down to a depth of 60 ft bgs. Surface and subsurface soils adjacent to but not beneath the burial pits are not part of this investigation and will be evaluated through the SOU. Likewise, the RGA is not part of this investigation and will be evaluated through the GWOU (with the exception of two borings advanced to the RGA to evaluate upgradient and downgradient contaminant levels at SWMUs 2 and 3. Borings adjacent to the NSDD will be advanced to a depth of 15 ft bgs to evaluate impacts from the pipeline that once discharged leachate from SWMU 3 into the NSDD.

9.1 SAMPLING MEDIA AND METHODS

This section identifies the different media to be sampled during the investigation and specifies methods for collecting the samples. Two types of sampling and data collection activities will be performed—nonintrusive data collection (surface geophysics) and intrusive media sampling (surface and subsurface soil, and groundwater). Investigation activities will use standard industry practices that are consistent with EPA procedures and protocols.

9.1.1 Non-Intrusive Data Collection – Geophysical Surveys

Geophysical surveys of SWMUs 7 and 30 and 145, using several methods, will be conducted prior to sampling activities. Because these SWMUs consist of one or more burial pits of various depths that are filled with a heterogeneous collection of wastes and backfill soils, the BGOU represents a difficult target for geophysical characterization. Magnetic properties of the metal drums and buried metal scrap offer the best contrast with the native soils for imaging.

First, an EM-61 magnetometer survey will be conducted at the surface of SWMUs 7 and 30 and 145 to delineate the burial pits exact location and extent. The EM-61 survey will be implemented along continuous lines spaced 4 to 5 ft apart, covering an area that will extend approximately 10 ft beyond the currently identified burial pit edges. A data logger or Ultrasonic Ranging and Data (USRAD) System will be employed for data acquisition.

If the EM-61 method proves ineffective for delineating the burial pits, a high-frequency Ground Penetrating Radar (GPR) survey will be conducted. With GPR, a low-frequency antenna (50 MHz) maximizes the depth of investigation, but reduces the quality of response. From previous use of GPR on-site, a resolution of 4 to 6 ft bgs is expected, which is adequate to delineate to the top of the waste cells. The GPR will be implemented using a towed array system over an area extending 10 ft beyond the SWMU boundary.

9.1.2 Intrusive Sampling

Various media samples will be collected to characterize areas that have been evaluated as having identified data gaps. The samples will be collected using DOE Prime Contractor-approved procedures and will be submitted to an SMO-approved, fixed-base, analytical laboratory for analysis. Field instruments will be used to screen media for VOCs and radiological contamination to evaluate conditions for the workers.

9.1.2.1 Subsurface soil sampling

Subsurface soil samples from soil borings will be collected in accordance with DOE Prime Contractor-approved procedures. The specific sample equipment selected will be dependent on the drilling technology being used. One potential method for angular boring is use of a track-mounted rig that is capable of both direct-push (DPT) and hollow-stem auger (HSA) drilling. This track-mounted drill rig utilizes auger flights to advance the borings to sample depth. Push rods then are used to advance an acetate tube beyond the augered depth to collect undisturbed soil samples. Soil samples for VOC analysis will be removed from the base of the acetate sleeve as soon as the sleeve is removed from the core barrel. Then the sleeve will be cut open and the lithology of the sample described and recorded. After the description of the lithology is completed, the soil will be placed in a clean bowl and mixed thoroughly to homogenize the sample. The resulting mixture will be placed in the appropriate sample jars for analysis. The acetate sleeve and any remaining soil will be handled as investigation-derived waste (IDW).

This track-mounted rig, capable of DPT and HSA, also is capable of drilling at an angle ranging from vertical (90°) to 27°. This range of versatility will be useful because it will facilitate greater penetration under the burial cells, especially in areas where surface obstructions limit drill rig placement adjacent to the burial cells. Subsurface soil samples will be collected from both vertical and angle borings.

Potential drilling methods for vertical borings include dual-wall reverse circulation (DWRC), HSA, and rotary sonic. Soil sampling methods would be similar to that described above.

Angle Borings

Subsurface soil samples from the angle borings will be collected generally from 8 to 10 ft, 13 to 15 ft, 28 to 30 ft, 43 to 45 ft, and 58 to 60 ft bgs (a total of five soil samples per boring). Sampling intervals for burial pits greater than 15 ft bgs will not begin until the angular boring is near 15 ft bgs. (Note: These sample depths represent vertical depth below the burial cells. Distance along the actual borehole will vary based on actual angle of penetration under each cell.) Sample collection from the angle borings will begin once the boring has penetrated the soil beneath each burial cell, based on the extent of set-back of the rig and the angle of penetration at each location. Set-back will be minimized as much as practical, but will be a consideration in order to avoid drilling into a burial cell. Field screening instruments [e.g., photoionization detectors (PIDs) and radiological pancake-type probes] will be used to measure VOC and radiological contamination of drill cuttings as the boring is advanced to evaluate conditions for the workers.

Use of a track-mounted drill rig capable of drilling and sampling with DPT and HSA will allow some variability in the angle of each boring - between 27° and 90°. This flexibility will allow for greater penetration under the burial cells where space to set the rig back permits. In areas where space adjacent to the burials cells is limited, or confined to immediately adjacent to the burial cell, steeper-angle borings may be advanced. The specific angle for each location will be determined in the field and will be based on information regarding the aerial extent and depth of the burial cell and the extent of space around the burial cell in which to position the rig. (In all cases, the intent will be to drill as close to the burial pit as reasonably feasible without actually penetrating the cell.)

If the angle of the boring is ~27° and the maximum depth that can be reached by the drilling equipment is 60 ft, then the horizontal distance the boring will reach from the edge of the disposal cell inwards is ~130 ft, assuming the drill rig is at the edge of the disposal cell. Soil borings will be abandoned by grouting with high solids bentonite (30% solids).

Vertical Borings

Samples collected from the vertical borings generally will be from the following depths: 0 to 1 ft, 3 to 5 ft, 8 to 10 ft, 13 to 15 ft, 28 to 30 ft, 43 to 45 ft, and 58 to 60 ft bgs (a total of seven soils samples per boring). Field screening instruments (e.g., PIDs and radiological pancake-type probes) will be used to measure VOC and radiological contamination of drill cuttings as the boring is advanced to evaluate conditions for the workers.

9.1.2.2 Groundwater sampling

Groundwater samples will be collected from multiple discrete depths within the UCRS and RGA using temporary borings at various locations. Water sampling in the UCRS will be dictated by the presence of water-bearing zones—typically one or two samples will be collected using a hydro-punch advanced ahead of the augers. Water sampling in the RGA will begin at the top of the RGA (approximately 60 ft bgs) and continue at 10 ft intervals to the base of the RGA (approximately 100 ft bgs). This strategy will result in a total of two to six water samples collected from each boring, depending on the presence of water-bearing zones in the UCRS and the thickness of the RGA present in the boring. The borings will be drilled using methods that allow collection of discrete-depth water samples with minimum vertical cross-contamination.

Discrete RGA groundwater samples will be collected as soon as each water sample depth is reached and drilling stops. A water-level indicator will be placed down the boring, and the water level will be monitored each minute for up to 15 minutes to determine how fast the water level returns to equilibrium. The faster the water level stabilizes, the more permeable the interval being sampled and the greater the potential for the interval to be a preferred pathway for contaminant migration. After the groundwater level stabilizes (or 15 minutes, whichever comes first), the sampling pump will be lowered into the boring and the sample collection process will begin. The first step will be to purge the drill pipe. A bladder pump may be used to purge the boring and to collect water samples. Purging is required to eliminate the impact of the drilling fluid (air for DWRC and potable water for rotary sonic or HSA) on the interval being sampled. Since sampling will take place immediately after drilling ceases, there will be no stagnant water to remove from the boring and, therefore, no minimum purge volume. The water sample will be collected after sufficient water has been purged to allow geochemical parameters (i.e., pH, dissolved oxygen, conductivity, and temperature) to stabilize within the boring and to return to original aquifer conditions, as measured in existing MWs in the area. The geochemical parameters will be considered stabilized when the following criteria are met:

- At least three measurements taken three minutes apart have consistent readings for temperature, conductivity, and pH;
- Temperature measurements agree within 1°C;
- Conductivity measurements agree within 10%; and
- pH measurements agree within 0.5 units.

Values from area wells will be referenced to confirm that the stabilized values represent groundwater values and are not the result of groundwater being displaced by a large volume of potable water invading the sample interval during drilling. There is some natural variance across the area, so values from existing wells will be used as indicators of aquifer conditions, but not as specific reference values to determine stabilization within an individual boring. The pH value is the most useful indicator since the pH of RGA groundwater is around 6.5 units, while the pH of the PGDP potable water that may be used during drilling is 7.5 to 8 units.

When the geochemical parameters have stabilized, the flow rate of the sampling pump will be adjusted to 200 mL/minute or less for sampling. Groundwater samples will be collected in accordance with SWMU-specific sampling plans. During each sampling event, the field parameters of depth to water, groundwater temperature, pH, specific conductance, oxidation reduction potential (Eh), and dissolved oxygen will be collected. After sampling is completed, the sample tubing and pump will be removed from the boring. The pump and tubing will be decontaminated in accordance with DOE Prime Contractor-approved procedures prior to its next use. Before drilling resumes, the groundwater level will be measured again to determine if any changes occurred during sampling. Filtered (dissolved) and unfiltered (suspended) groundwater samples will be analyzed for metals and radionuclides. Filtration with a 0.45 micron filter will occur prior to acidification. Both the suspended and dissolved phases will be analyzed to assess distribution in the system and the potential for a constituent to be transported via groundwater to a receptor.

An alternative groundwater sampling collection method is the HSA/DPT combination, which permits the use of DPT-type water sampling probes within the RGA. The drive-point water sampler is pushed or driven below the bottom of the augers, permitting collection of a relatively undisturbed water sample with minimal cross-contamination. When the drive-point sampler has reached the target depth, the mechanism allowing collection of a groundwater sample will be activated. Groundwater will be pumped to the surface, typically with an inertial pump or mechanical bladder pump, although some air- or inert gas-driven systems are available and are preferred. The small inner diameter of the drive-point sampler limits the types of pumps that can be used with this system. A small amount of water, typically less than a gallon, will be purged to reduce the initial turbidity of the water sample. Since sampling will take place immediately after drilling ceases, there will be no stagnant water to remove from the boring and, therefore, no minimum purge volume. The water sample will be collected after sufficient water has been purged, to allow geochemical parameters (i.e., pH, dissolved oxygen, conductivity, and temperature) to stabilize within the boring.

9.1.2.3 Lithologic description

The description of the physical appearance of the soils being sampled is a basic piece of information acquired from each new boring. Depth, color, grain size, and texture facilitate the development a three-dimensional picture of the subsurface sediments. Several methods are available for collecting samples for description, each dependent on the drilling method being used.

9.2 SAMPLE ANALYSIS

Sample analysis for this investigation consists of analysis of groundwater samples; analysis of sediment, surface, and subsurface soil samples; and characterization of project-generated waste materials. Specific analytical requirements, methods, and procedures are described in the Quality Assurance Project Plan (QAPP), Chapter 11.

When available and appropriate for the sample matrix, the latest versions of SW-846 methods adopted by the lab will be used. When not available, other nationally recognized methods, such as those of EPA, DOE, and the American Society for Testing and Materials (ASTM) will be used. A Nuclear Regulatory Commission-licensed, fixed-base laboratory will perform laboratory analyses.

9.3 SITE-SPECIFIC SAMPLING PLANS

A review of existing data for each of the BGOU SWMUs (Chapter 5) has been conducted to determine the following:

- SWMU-specific COCs,
- Extent and quality of existing data, and
- Sufficiency of data to support an FS for remedial options.

Where data are absent or insufficient to fully characterize the nature and extent of contamination and to support remedy selection, specific data gaps were identified. These data gaps are the basis for additional sampling under this work plan. The following sections address each SWMU individually.

Because sampling locations shown in the subsequent figures are estimated, it is probable that some of these locations will be adjusted based on geophysical survey results or other site information obtained. If any of the sampling locations shown for any of the SWMUs require adjustment (greater than ~16 ft), EPA and KDEP will be informed and their approval obtained prior to implementing the change.

Table 9.1 displays and summarizes the sampling strategy, including the total number of planned samples. Contingency samples are not included in the sample totals.

Table 9.1 BGOU Investigation and Sampling Summary

<table>
<tr><th>SWMU</th><th>Surface geophysics</th><th>Angle borings</th><th>Vertical borings</th><th>Soil samples</th><th>Groundwater samples</th><th>RGA wells (groundwater samples)</th></tr>
<tr><td rowspan="2">SWMU 2</td><td rowspan="2">No</td><td rowspan="2">2</td><td rowspan="2">1[1]</td><td>10</td><td>2</td><td rowspan="2">1 (4 samples)</td></tr>
<tr><td>7[1]</td><td>6[3]</td></tr>
<tr><td rowspan="2">SWMU 3</td><td rowspan="2">No</td><td rowspan="2">4</td><td>1[1]</td><td>20</td><td>4</td><td rowspan="2">1 (4 samples)</td></tr>
<tr><td>6</td><td>31[2]</td><td>6[3]</td></tr>
<tr><td>SWMU 4</td><td colspan="6">No additional data required for BGOU RI</td></tr>
<tr><td></td><td colspan="6"></td></tr>
<tr><td>SWMU 5</td><td>No</td><td>3</td><td>0</td><td>15</td><td>3</td><td>0</td></tr>
<tr><td>SWMU 6</td><td>No</td><td>4</td><td>0</td><td>20</td><td>4</td><td>0</td></tr>
<tr><td>SWMU 7 and 30</td><td>Yes</td><td>12</td><td>3</td><td>81</td><td>30</td><td>0</td></tr>
<tr><td>SWMU 145</td><td>Yes</td><td>7</td><td>0</td><td>35</td><td>7</td><td>0</td></tr>
<tr><td>TOTAL</td><td>NA</td><td>32</td><td>11</td><td>219</td><td>62</td><td>2 (8)</td></tr>
</table>

[1] Will be necessary only if current RGA groundwater wells are not acceptable and new wells are installed.
[2] Includes seven samples from one boring advanced to 60 ft and 24 samples from six borings advanced to 15 ft.
[3] Includes six samples from one boring advanced to 60 ft that will be necessary only if the existing MWs are not suitable.

9.3.1 SWMU 2

<table>
<tr><td>SWMU 2</td><td>Data Gaps:
There are no soil or groundwater data at depth adjacent to the burial ground or from beneath the burial ground.
Evaluate if additional contaminants (other than what have been identified in previous investigations) seeping from the bottom of the burial cell is unknown.
Soils immediately beneath the burial pits may have become contaminated and are now a secondary contaminant source is unknown.
The SWMU is located above a TCE plume; however, upgradient and downgradient data are not available that might indicate whether SWMU 2 is contributing to this plume.

Sampling Strategy:
Drill two angle borings under the burial area and collect soil samples and UCRS groundwater samples (if sufficient amount of groundwater is available).
Sample existing RGA upgradient and downgradient wells, or install and sample new upgradient and downgradient wells. These wells will be upgradient and downgradient to SWMUs 2 and 3.</td></tr>
</table>

9.3.1.1 Data gaps

- There are no soil or groundwater data at depth adjacent to the burial ground or from beneath the burial ground.
- Evaluate if additional contaminants (other than what have been identified in previous investigations) seeping from the bottom of the burial cell.
- Soils immediately beneath the burial pits may have become contaminated and are now a secondary contaminant source is unknown.
- The SWMU is located above a TCE plume; however, upgradient and downgradient data are not available that might indicate whether SWMU 2 is contributing to this plume.

9.3.1.2 Sampling plan

The sampling approach has been designed to determine if there have been releases from the bottom of the burial ground and, if so, if these releases are contributing to the TCE plume. The following paragraphs outline the sampling and analytical requirements for SWMU 2 and summarize the rationale for the locations selected. Figure 9.1 shows the proposed sampling locations for the site and displays various cross-sections of the burial cell and the maximum penetration possible for the angle borings. (Note this and subsequent figures for each successive SWMU are intended to graphically represent the extent of penetration under each cell, but are not intended to display graphically each proposed boring. Unique configurations of set-back and boring angles are presented.)

Soil Boring Locations. Two angle soil borings and one vertical soil boring during the installation of a new monitoring well will be drilled under or alongside the burial ground, as shown on Table 9.1. (Note the vertical boring will be drilled only if the existing monitoring well is determined unsuitable (criteria described on page 9-11) as an RGA groundwater monitoring well.) Surface and subsurface soil samples will be collected from these borings and analyzed for the selected VOCs, radionuclides, and metals, including uranium metal listed in Table 9.2.

An attempt will be made to collect a UCRS groundwater sample from each angle boring, depending on the presence of groundwater. Groundwater sample aliquots will be collected for the parameters listed in Table 9.3

If the vertical boring is necessary for the installation of a new monitoring well, groundwater samples will be collected from multiple discrete depths within the UCRS and RGA. Water sampling in the UCRS will be dictated by the presence of water-bearing zones—typically one or two samples will be collected using a hydro-punch advanced ahead of the augers. Water sampling in the RGA will begin at the top of the RGA (approximately 60 ft bgs) and continue at 10 ft intervals to the base of the RGA (approximately 100 ft bgs). This strategy will result in a total of two to six water samples collected from each boring, depending on the presence of water-bearing zones in the UCRS and the thickness of the RGA present in the boring. Groundwater sample aliquots will be collected for the parameters listed in Table 9.3

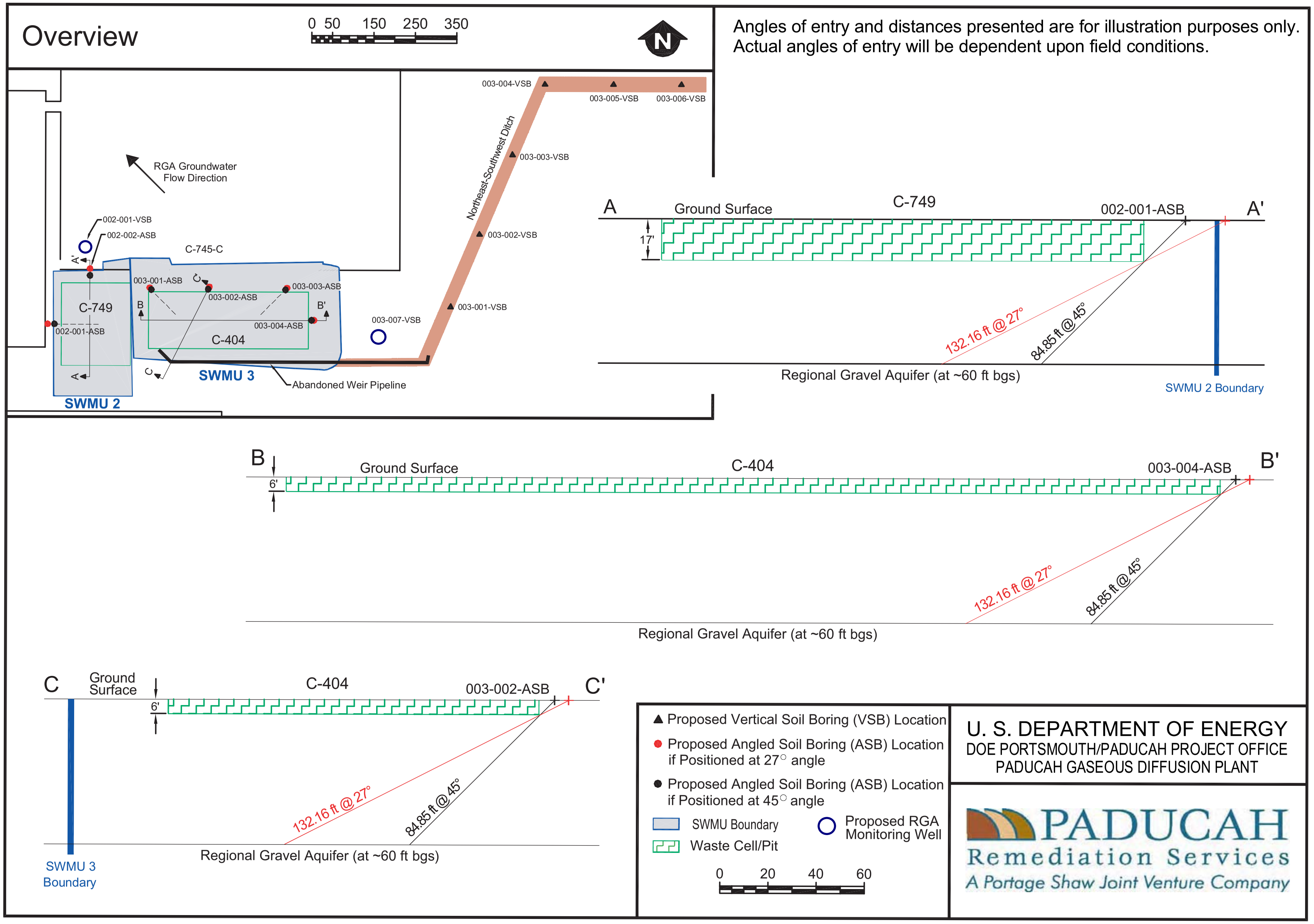


Figure 9.1. SWMUs 2 and 3 BGOU RI/FS Proposed Sampling Locations

Table 9.2 SWMUs 2 and 3 Soil Analyte and Method Detection List

Reporting Limit (µg/kg)	Target Compound List volatiles SW-846, 8260		
10	Benzene	1,1-Dichloroethane	Tetrachloroethene
	Bromodichloromethane	1,2-Dichloroethane	Toluene
	Bromoform	1,1-Dichlorethene	trans-1,2-Dichloropropene
	Carbon disulfide	cis-1,2-Dichloroethene	trans-1,4-Dichloro-2-butene (100)
	Carbon tetrachloride	1,2-Dichloropropane	1,1,1-Trichloroethane
	Chlorobenzene	Ethyl methacrylate	1,1,2-Trichloroethane
	Chloroform	Ethyl benzene	Trichloroethene
	cis-1,3 Dichloroprene	Iodomethane	Trichlorofluoromethane
	trans-1,3-Dichloropropene	Methylene chloride	1,2,3-Trichloropropane
	cis-1,3-Dichloropropene	Styrene	trans-1,2 Dichloroethene
	Dibromochloromethane	Dichlorodifluoromethane	*m,p-* xylene (20 ug/kg)
	Dibromomethane	1,1,2,2-Tetrachoroethane	*o-* xylene
	1,2-Dibromomethane	1,1,1,2-Tetrachloroethane	Chloromethane
	Bromomethane	2-Chloroethyl vinyl ether	Vinyl chloride
	Chloroethane	2-Butanone	Vinyl acetate
	4-Methyl-2-pentanone	Acrolein	2-Hexanone
	Acetone	Acrylonitrile	

(pCi/g)	Radionuclides	Method
5	Gross alpha	EPA-900
5	Gross beta	EPA-900
3	Uranium-234	Alpha Spec
2	Uranium-235	Alpha Spec
2	Uranium-238	Alpha Spec
8	Technetium-99	Liquid Scintillation
3	Thorium-228	Alpha Spec
4	Thorium-230	Alpha Spec
3	Thorium-232	Alpha Spec
3	Neptunium-237	Alpha Spec
6	Plutonium-238	Alpha Spec
4	Plutonium-239/240	Alpha Spec
3	Americium-241	Alpha Spec
0.5	Cesium-137	Gamma Spec

(mg/kg)	Metals	Method
20	Aluminum	6010
10	Antimony	6010
2.5	Barium	6010
0.5	Beryllium	6010
2	Cadmium	6010
100	Calcium	6010
2.5	Chromium	6010
2.5	Cobalt	6010
2.5	Copper	6010
20	Iron	6010
20	Lead	6010
5	Magnesium	6010
2.5	Manganese	6010
5	Molybdenum	6010
5	Nickel	6010
2.5	Silver	6010
200	Sodium	6010
2	Thallium	6020
1	Uranium	6010
2.5	Vanadium	6010
20	Zinc	6010
1	Arsenic	6020
20	Selenium	6010
0.02	Mercury	7471

Table 9.3 SWMUs 2 and 3 Groundwater Analyte and Method Detection List

Reporting Limit (µg/L)	Target Compound List volatiles SW-846, 8260		
5	Benzene	Dichlorodifluoromethane	Tetrachloroethene
	Bromodichloromethane	1,1-Dichloroethane	Toluene
	Bromoform	1,2-Dichloroethane	trans-1,2-Dichloropropene
	Carbon disulfide	1,1-Dichlorethene	trans-1,4-Dichloro-2-butene (100)
	Carbon tetrachloride	cis-1,2-Dichloroethene	1,1,1-Trichloroethane
	Chlorobenzene	1,2-Dichloropropane	1,1,2-Trichloroethane
	Chloroform	Ethyl methacrylate	Trichloroethene
	cis-1,3-Dichloroprene	Ethyl benzene	Trichlorofluoromethane
	trans-1,3-Dichloropropene	Iodomethane	1,2,3-Trichloropropane
	cis-1,3-Dichloropropene	Methylene chloride	trans-1,2 Dichloroethene
	Dibromochloromethane	Styrene	*m,p-* xylene (20 ug/L)
	Dibromomethane	1,1,2,2-Tetrachoroethane	*o-* xylene
	1,2-Dibromomethane	1,1,1,2-Tetrachloroethane	Vinyl chloride (2 ug/L)
10	Bromomethane	2-Chloroethyl vinyl ether	Chloromethane
	Chloroethane		
50	2-Hexanone	4-Methyl-2-pentanone	Vinyl acetate
100	Acetone	Acrylonitrile	2-Butanone
	Acrolein		
(pCi/L)	**Radionuclides**		**Method**
3	Gross alpha		EPA-900
3	Gross beta		EPA-900
0.4	Uranium-234 (Filtered and Unfiltered)		Alpha Spec
0.4	Uranium-235 (Filtered and Unfiltered)		Alpha Spec
0.4	Uranium-238 (Filtered and Unfiltered)		Alpha Spec
1	Technetium-99		Liquid Scintillation
0.4	Thorium-228		Alpha Spec
0.4	Thorium-230		Alpha Spec
0.4	Thorium-232		Alpha Spec
0.5	Neptunium-237		Alpha Spec
0.4	Plutonium-238		Alpha Spec
0.4	Plutonium-239/240		Alpha Spec
0.4	Americium-241		Alpha Spec
0.4	Cesium-137		Gamma Spec
(mg/L)	**Metals (Filtered and Unfiltered)**		**Method**
0.2	Aluminum		6010
0.005	Antimony		6010
0.01	Barium		6010
0.005	Beryllium		6010
0.0006	Cadmium		6010
5	Calcium		6010
0.01	Chromium		6010
0.01	Cobalt		6010
0.025	Copper		6010
0.05	Iron		6010
0.0013	Lead		6010
0.5	Magnesium		6010
0.01	Manganese		6010
0.001	Molybdenum		6010
0.04	Nickel		6010
0.01	Silver		6010
0.5	Sodium		6010
0.002	Thallium		6010
0.001	Uranium		6010
0.02	Vanadium		6010
0.02	Zinc		6010
0.001	Arsenic		6020
0.04	Selenium		6010
0.00001	Mercury		7471

Groundwater MWs. Two existing MWs at SWMUs 2 and 3 (MW 67 and MW 76) will be evaluated during this RI to determine if they are suitable to serve as upgradient and downgradient control points. The criteria listed below will be applied, in order, to each of the wells for determining the well's suitability. Should a well fail to positively meet any of these criteria, the well no longer will be considered for the investigation and installation of a new well will be scheduled.

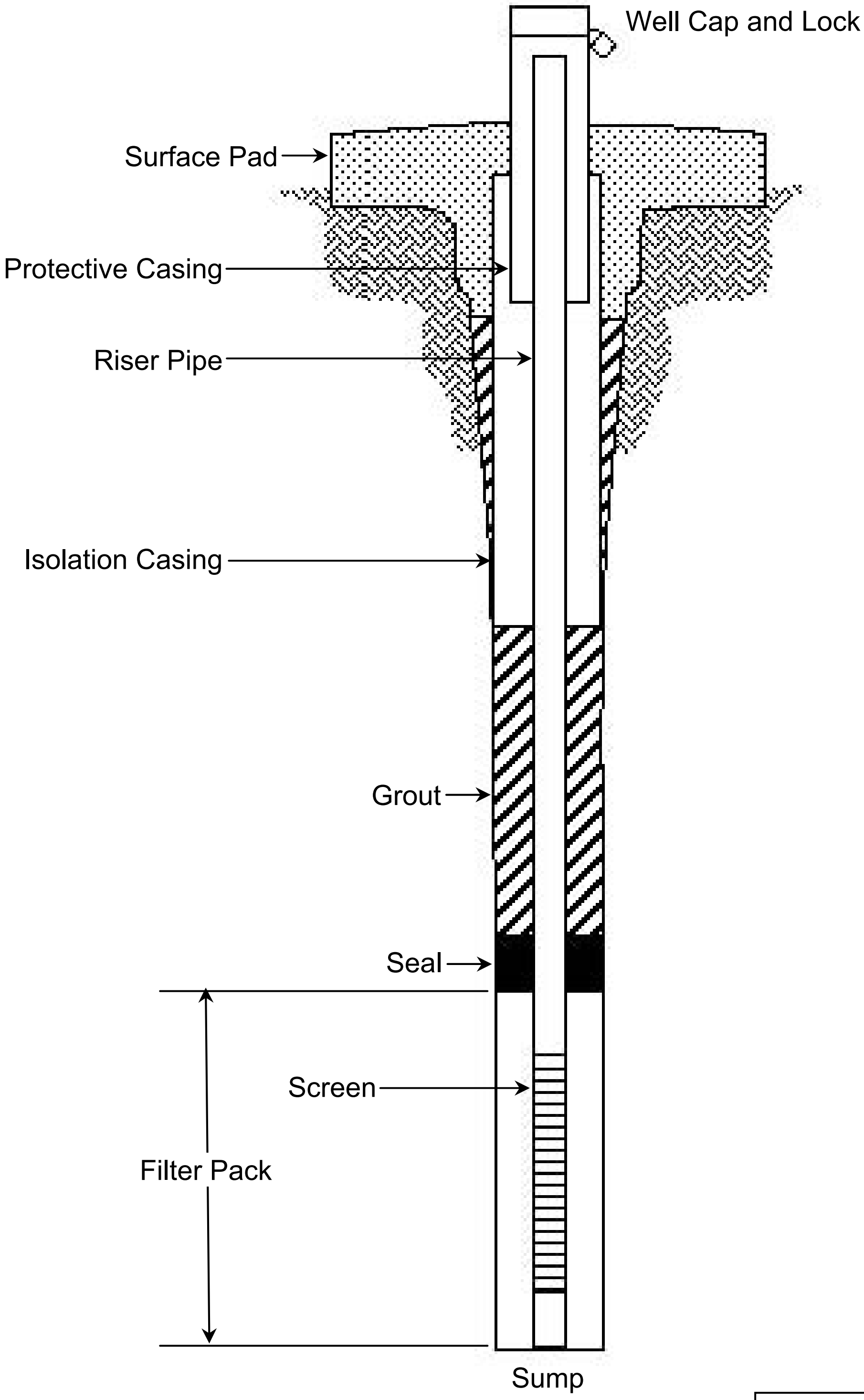
- Evaluation of groundwater flow to determine gradient direction with respect to well location;
- Review of well construction details and surrounding lithology to determine well's adequate placement in the RGA; and
- Downhole video camera inspection to determine existence/extent of biofouling and integrity of well casing and screen.

If the well positively meets the criteria, it will be rehabilitated and redeveloped, if needed, to attain appropriate RI-quality samples for the parameters listed in Table 9.3.

If these wells are determined not to be suitable, then one RGA groundwater monitoring well will be installed downgradient and one RGA groundwater MW will be installed upgradient. Specifications for these wells will meet the requirements of 401 KAR 48:300. Data collected during the angle boring sampling will be used to determine the placement of these wells. Based on these data, a determination of the depth to set screens will be made and an MW will be installed. After development, these wells will be sampled for the parameters listed in Table 9.3. (Note, that the data from these well also will be used to address the same data gap at SWMU 3). Figure 9.2 is a diagram of the construction of the proposed MWs.

9.3.2 SWMU 3

SWMU 3	**Data Gaps:** There are no soil data at depth immediately adjacent to the impoundment or from beneath the impoundment. Because the SWMU is located above a TCE plume, upgradient and downgradient data are not available that might indicate whether SWMU 3 is contributing to this plume; however, the current well network is being impacted by the existing TCE plume. There is no information on potential subsurface soil contamination directly beneath the burial cell. The potential for additional contaminants (other than what have been identified in previous investigations) seeping from the bottom of the burial cell is unknown. The potential that the soils immediately beneath the burial cell may have become contaminated and are now a secondary contaminant source is unknown. There are no surface or subsurface soil historical data along the ditches around SWMU 3 and in the ditch leading to the NSDD. **Sampling Strategy:** Drill four angle borings around, and under, the burial cell, and collect soil samples and UCRS groundwater samples (if sufficient amount of groundwater is available). Sample existing RGA upgradient and downgradient wells (not part of the current network), or install and sample new upgradient and downgradient wells. These wells will be upgradient and downgradient to SWMUs 2 and 3. Collect surface and shallow subsurface soil samples from six vertical borings from the ditches and along the ditch leading to the NSDD.



U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

Figure 9.2. Example Monitoring Well Diagram

PADUCAH Remediation Services
A Portage Shaw Joint Venture Company

9.3.2.1 Data gaps

- There are no soil data at depth immediately adjacent to the impoundment or from beneath the impoundment. Because the SWMU is located above a TCE plume, upgradient and downgradient data are not available that might indicate whether SWMU 3 is contributing to this plume; however, the current well network is being impacted by the existing TCE plume.

- There is no information on potential subsurface soil contamination directly beneath the burial cell.

- The potential for additional contaminants (other than what have been identified in previous investigations) seeping from the bottom of the burial cell is unknown.

- The potential that the soils immediately beneath the burial cell may have become contaminated and are now a secondary contaminant source is unknown.

- There are no surface or subsurface soil historical data along the ditches around SWMU 3 and in the ditch leading to the NSDD.

9.3.2.2 Sampling plan

The sampling approach has been designed to evaluate whether there have been releases from the bottom of the impoundment and, if so, if these releases are contributing to the TCE plume and if there is subsurface contamination along the ditch areas.

The following paragraphs outline the sampling and analytical requirements for SWMU 3 and summarize the rationale for the locations selected. Figure 9.1 shows the proposed sampling locations for the site. Figure 9.1 displays a cross-section of the burial cell and the maximum penetration possible of the angle borings.

Soil Boring Locations. Four angle soil borings will be drilled under the impoundment and one vertical boring will be advanced upgradient of the burial cell during the installation of an MW. (Note the vertical boring will be drilled only if the existing MW is determined unsuitable (criteria described on page 9-11) as an RGA groundwater MW.) Six vertical borings (using DPT) will be advanced to a depth of 15 ft bgs along the ditch areas. Soil samples will be collected from each of the soil borings and will be analyzed for parameters listed in Table 9.2.

An attempt will be made to collect a UCRS groundwater sample from each angle boring, depending on the presence of groundwater. Groundwater sample aliquots will be collected for the parameters listed in Table 9.3.

If the vertical boring is necessary for the installation of a new MW, groundwater samples will be collected from multiple discrete depths within the UCRS and RGA. Water sampling in the UCRS will be dictated by the presence of water-bearing zones—typically one or two samples will be collected using a hydro-punch advanced ahead of the augers. Water sampling in the RGA will begin at the top of the RGA (approximately 60 ft bgs) and continue at 10 ft intervals to the base of the RGA (approximately 100 ft bgs). This strategy will result in a total of two to six water samples collected from each boring, depending on the presence of water-bearing zones in the UCRS and the thickness of the RGA present in the boring. Groundwater sample aliquots will be collected and analyzed for the parameters listed in Table 9.3.

No groundwater samples will be collected from the vertical borings advanced along the ditches.

Groundwater MWs. As described in Section 9.3.1.2, RGA samples will be collected from existing wells. If there are no existing wells suitable for sampling, then new RGA wells will be installed and sampled.

9.3.3 SWMU 4

SWMU 4	**Data Gaps:** None identified. The site has been characterized sufficiently to meet RI/FS goals.

9.3.3.1 Data gaps

For purposes of conducting the BGOU RI, the nature and extent of contamination at SWMU 4 have been adequately characterized. No additional data are required during the RI, and future data needs regarding remedy selection can be identified and collected during the FS and subsequent treatability studies (if required).

9.3.3.2 Sampling plan

Additional sampling is not recommended for SWMU 4 at this time, based on sampling data collected during the WAG 3 RI/FS and the Southwest Plume Groundwater SI.

9.3.4 SWMU 5

SWMU 5	**Data Gaps:** Previous investigations did not fully characterize the waste stream, based on existing records of waste disposal. **Sampling Strategy:** Drill three angle borings around SWMU 5, in targeted areas. Collect soil samples and UCRS groundwater samples (if sufficient amount of groundwater is available).

9.3.4.1 Data gaps

Previous investigations did not fully characterize the SWMU 5 waste stream, based on existing records of waste disposal

9.3.4.2 Sampling plan

The sampling approach has been designed to evaluate whether there have been releases from the bottom of the burial cells along the northern edge of the SWMU where the pits contents are unknown and at the southeast corner where the earliest waste is thought to have been placed.

The following paragraphs outline the sampling and analytical requirements for SWMU 5. Figure 9.3 shows the proposed sampling locations for the site.

Soil Boring Locations. Three angle borings will be drilled under the burial cells to collect soils from beneath the waste disposal cells. The angled borings will be drilled perpendicular to the SWMU boundary in order to optimize sampling beneath the cells. Soil samples will be collected from each of the angle soil borings and will be analyzed for selected radionuclides and metals (including uranium) identified in Table 9.4.

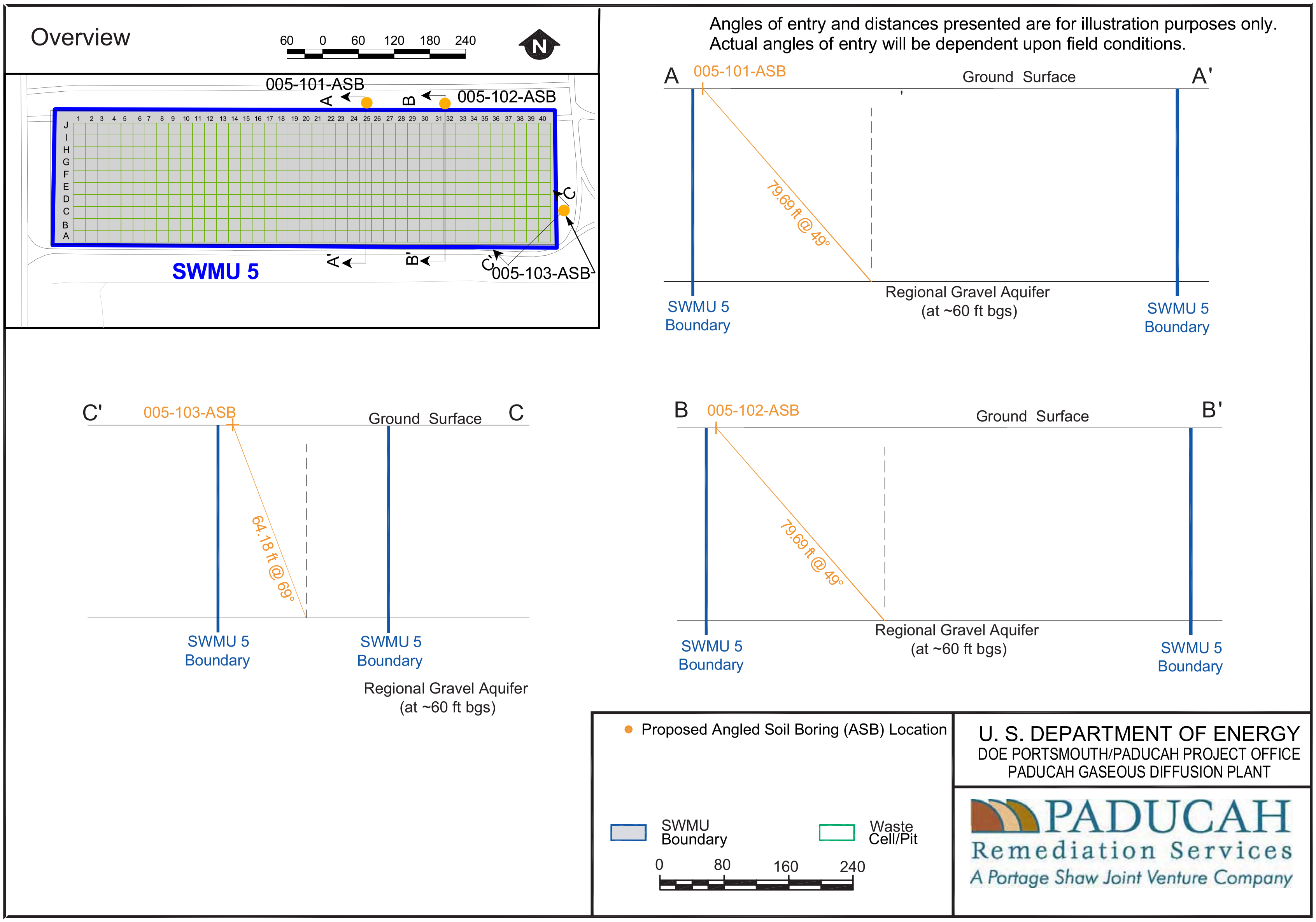


Figure 9.3. SWMU 5 BGOU RI/FS Proposed Sampling Locations

Table 9.4 SWMU 5 Soil Analyte and Method Detection List

Reporting Limit (pCi/g)	Radionuclides	Method
5	Gross alpha	EPA-900
5	Gross beta	EPA-900
3	Uranium-234	Alpha Spec
2	Uranium-235	Alpha Spec
2	Uranium-238	Alpha Spec
8	Technetium-99	Liquid Scintillation
3	Thorium-228	Alpha Spec
4	Thorium-230	Alpha Spec
3	Thorium-232	Alpha Spec
3	Neptunium-237	Alpha Spec
6	Plutonium-238	Alpha Spec
4	Plutonium-239/240	Alpha Spec
3	Americium-241	Alpha Spec
0.5	Cesium-137	Gamma Spec
Reporting Limit (mg/kg)	**Metals**	**Method**
20	Aluminum	6010
10	Antimony	6010
2.5	Barium	6010
0.5	Beryllium	6010
2	Cadmium	6010
100	Calcium	6010
2.5	Chromium	6010
2.5	Cobalt	6010
2.5	Copper	6010
20	Iron	6010
20	Lead	6010
5	Magnesium	6010
2.5	Manganese	6010
5	Molybdenum	6010
5	Nickel	6010
2.5	Silver	6010
200	Sodium	6010
2	Thallium	6020
1	Uranium	6010
2.5	Vanadium	6010
20	Zinc	6010
1	Arsenic	6020
20	Selenium	6010
0.02	Mercury	7471

An attempt also will be made to collect UCRS groundwater samples from each boring, depending on the presence of groundwater. Groundwater sample aliquots will be collected for parameters listed in Table 9.5.

Table 9.5 SWMU 5 Groundwater Analyte and Method Detection List

Reporting Limit (pCi/L)	Radionuclides	Method
3	Gross alpha	EPA-900
3	Gross beta	EPA-900
0.4	Uranium-234 (Filtered and Unfiltered)	Alpha Spec
0.4	Uranium-235 (Filtered and Unfiltered)	Alpha Spec
0.4	Uranium-238 (Filtered and Unfiltered)	Alpha Spec
1	Technetium-99	Liquid Scintillation
0.4	Thorium-228	Alpha Spec
0.4	Thorium-230	Alpha Spec
0.4	Thorium-232	Alpha Spec
0.5	Neptunium-237	Alpha Spec
0.4	Plutonium-238	Alpha Spec
0.4	Plutonium-239/240	Alpha Spec
0.4	Americium-241	Alpha Spec
0.4	Cesium-137	Gamma Spec
Reporting Limit (mg/L)	**Metals (Filtered and Unfiltered)**	**Method**
0.2	Aluminum	6010
0.005	Antimony	6010
0.01	Barium	6010
0.005	Beryllium	6010
0.0006	Cadmium	6010
5	Calcium	6010
0.01	Chromium	6010
0.01	Cobalt	6010
0.025	Copper	6010
0.05	Iron	6010
0.0013	Lead	6010
0.5	Magnesium	6010
0.01	Manganese	6010
0.001	Molybdenum	6010
0.04	Nickel	6010
0.01	Silver	6010
0.5	Sodium	6010
0.002	Thallium	6010
0.001	Uranium	6010
0.02	Vanadium	6010
0.02	Zinc	6010
0.001	Arsenic	6020
0.04	Selenium	6010
0.00001	Mercury	7471

9.3.5 SWMU 6

SWMU 6	**Data Gaps:** Areas have not been evaluated where there was radiologically-contaminated equipment stored during previous investigations. **Sampling Strategy:** Drill four angle borings near the location where the highest contamination was found previously. Collect soil samples and UCRS groundwater samples (if sufficient amount of groundwater is available).

9.3.5.1 Data gaps

- Areas have not been evaluated where there was radiologically-contaminated equipment stored during previous investigations.

9.3.5.2 Sampling plan

The sampling approach has been designed to evaluate whether there have been releases from the bottom of the burial cells in the southern half of the SWMU and to determine if the sporadic detects of radionuclide contamination in Burial Pit J are isolated occurrences or indicative of widespread contamination.

The following paragraphs outline the sampling and analytical requirements for SWMU 6 and summarize the rationale for the locations selected. Figure 9.4 shows the proposed sampling locations for the site.

Soil Boring Locations. Four angle borings will be drilled under the burial cells to collect soils from beneath the waste disposal cells. Soil samples will be collected from each of the angle soil borings and will be analyzed for selected radionuclides, metals (including uranium), and PCBs identified in Table 9.6.

An attempt also will be made to collect UCRS groundwater samples from each boring, depending on the presence of groundwater. Groundwater sample aliquots will be collected for parameters listed in Table 9.7.

Tables 9.6 and 9.7 can be found on the following pages.

Table 9.6 SWMU 6 Soil Analyte and Method Detection List

Reporting Limit (mg/kg)	TCL PCBs SW-846, 8082		
0.1	Aroclor-1016 Aroclor-1221 Aroclor-1232	Aroclor-1242 Aroclor-1248	Aroclor-1254 Aroclor-1260

Reporting Limit (pCi/g)	Radionuclides	Method
5	Gross alpha	EPA-900
5	Gross beta	EPA-900
3	Uranium-234	Alpha Spec
2	Uranium-235	Alpha Spec
2	Uranium-238	Alpha Spec
8	Technetium-99	Liquid Scintillation
3	Thorium-228	Alpha Spec
4	Thorium-230	Alpha Spec
3	Thorium-232	Alpha Spec
3	Neptunium-237	Alpha Spec
6	Plutonium-238	Alpha Spec
4	Plutonium-239/240	Alpha Spec
3	Americium-241	Alpha Spec
0.5	Cesium-137	Gamma Spec

Reporting Limit (mg/kg)	Metals	Method
20	Aluminum	6010
10	Antimony	6010
2.5	Barium	6010
0.5	Beryllium	6010
2	Cadmium	6010
100	Calcium	6010
2.5	Chromium	6010
2.5	Cobalt	6010
2.5	Copper	6010
20	Iron	6010
20	Lead	6010
5	Magnesium	6010
2.5	Manganese	6010
5	Molybdenum	6010
5	Nickel	6010
2.5	Silver	6010
200	Sodium	6010
2	Thallium	6020
1	Uranium	6010
2.5	Vanadium	6010
20	Zinc	6010
1	Arsenic	6020
20	Selenium	6010
0.02	Mercury	7471

TCL = Target Compound List

Table 9.7 SWMU 6 Groundwater Analyte and Method Detection List

Reporting Limit (µg/L)	TCL PCBs SW-846, 8082		
0.1	Aroclor-1016	Aroclor-1242	Aroclor-1254
	Aroclor-1221	Aroclor-1248	Aroclor-1260
	Aroclor-1232		

Reporting Limit (pCi/L)	Radionuclides	Method
3	Gross alpha	EPA-900
3	Gross beta	EPA-900
0.4	Uranium-234 (Filtered and Unfiltered)	Alpha Spec
0.4	Uranium-235 (Filtered and Unfiltered)	Alpha Spec
0.4	Uranium-238 (Filtered and Unfiltered)	Alpha Spec
1	Technetium-99	Liquid Scintillation
0.4	Thorium-228	Alpha Spec
0.4	Thorium-230	Alpha Spec
0.4	Thorium-232	Alpha Spec
0.5	Neptunium-237	Alpha Spec
0.4	Plutonium-238	Alpha Spec
0.4	Plutonium-239/240	Alpha Spec
0.4	Americium-241	Alpha Spec
0.4	Cesium-137	Gamma Spec
Reporting Limit (mg/L)	**Metals (Filtered and Unfiltered)**	**Method**
0.2	Aluminum	6010
0.005	Antimony	6010
0.01	Barium	6010
0.005	Beryllium	6010
0.0006	Cadmium	6010
5	Calcium	6010
0.01	Chromium	6010
0.01	Cobalt	6010
0.025	Copper	6010
0.05	Iron	6010
0.0013	Lead	6010
0.5	Magnesium	6010
0.01	Manganese	6010
0.001	Molybdenum	6010
0.04	Nickel	6010
0.01	Silver	6010
0.5	Sodium	6010
0.002	Thallium	6010
0.001	Uranium	6010
0.02	Vanadium	6010
0.02	Zinc	6010
0.001	Arsenic	6020
0.04	Selenium	6010
0.00001	Mercury	7471

TCL = Target Compound List

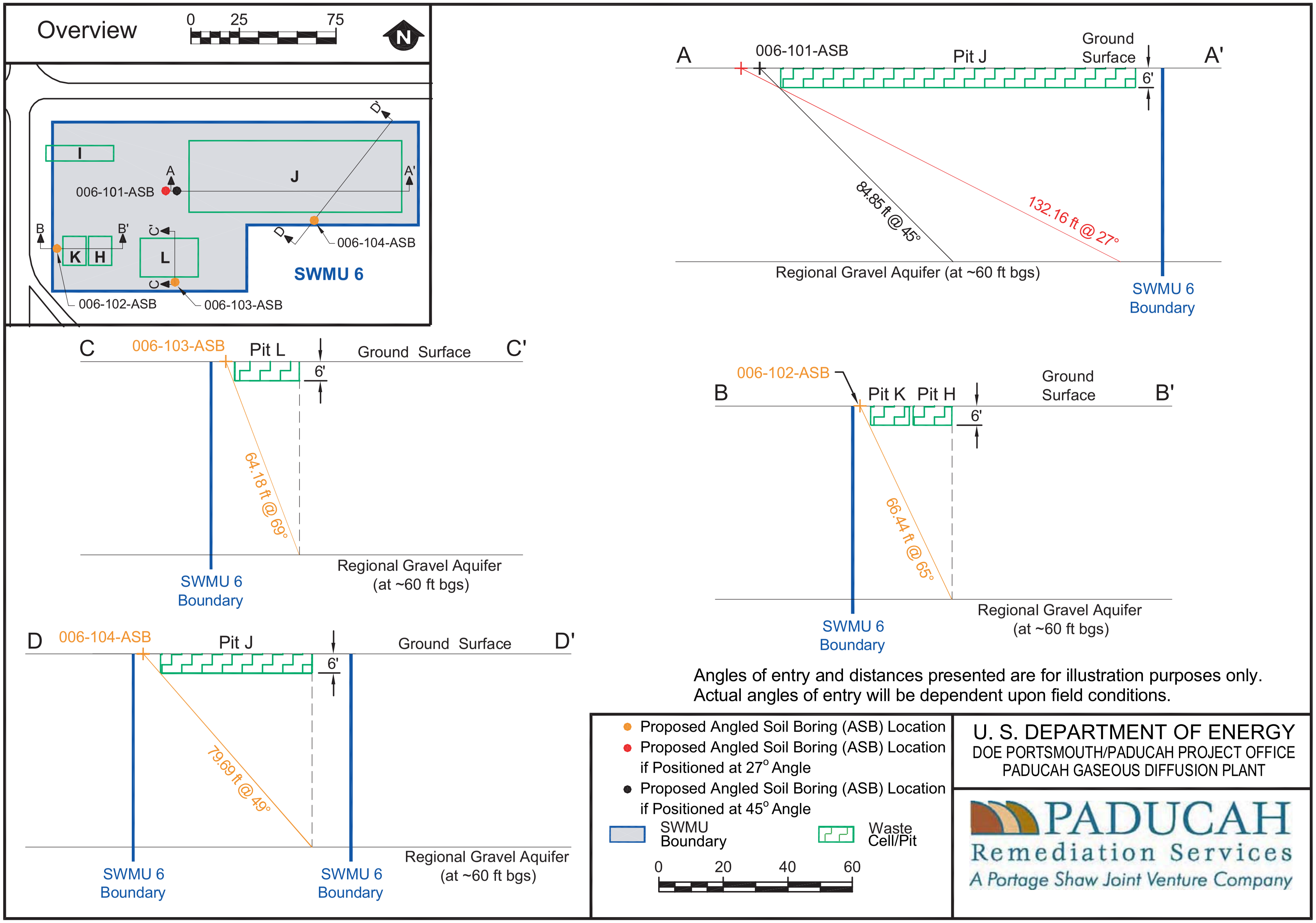


Figure 9.4. SWMU 6 BGOU RI/FS Proposed Sampling Locations

9.3.6 SWMUs 7 and 30

SWMUs 7 and 30	**Data Gaps:** There is no information on potential subsurface soil contamination directly beneath the burial pits. The potential for additional contaminants (other than what have been identified in previous investigations) seeping from the bottom of the burial cell is unknown. The potential that the soils immediately beneath the burial pits may have become contaminated and are now a secondary contaminant source is unknown. The lateral extent of the burial pits is not definitively known. **Sampling Strategy:** Conduct a geophysical survey to determine the pit boundaries where uncertainties have been identified and to define the anomalous areas. Drill twelve angle borings (one under each pit) and collect soil samples and UCRS groundwater samples (if sufficient amount of groundwater is available). Drill one vertical boring at the former Drum Mountain location and collect soil samples and UCRS groundwater samples (if sufficient amount of groundwater is available). Drill two vertical borings north of the pits and collect soil samples and groundwater samples to evaluate TCE contamination in shallow groundwater.

9.3.6.1 Data gaps

All boring information is from vertical borings that have been drilled beside or along the edges of the site or, in select instances, within the burial pits.

- There is no information on potential subsurface soil contamination directly beneath the burial pits.
- The potential for additional contaminants (other than what have been identified in previous investigations) seeping from the bottom of the burial cell is unknown.
- The potential that the soils immediately beneath the burial pits may have become contaminated and are now a secondary contaminant source is unknown.
- The lateral extent of the burial pits is not definitively known.

9.3.6.2 Sampling plan

The sampling approach has been designed to evaluate whether there have been releases from the bottom of the burial cells at SWMUs 7 and 30 and to characterize the nature and extent of the contamination in the subsurface soils and groundwater if there have been releases.

The following paragraphs outline the sampling and analytical requirements for SWMUs 7 and 30 and summarize the rationale for the locations selected. Figures 9.5 and 9.6 show the proposed sampling locations for the sites. Because of the prevalence of metals, PAHs, PCBs, VOCs, and various radionuclides (though all at low levels), samples will be analyzed for these contaminants.

Surface Geophysical Survey. The exact boundaries of the burial pits are not defined. Several geophysical methods are proposed; however, site-specific properties (e.g., fences, utilities, etc.) can interfere with the instruments.

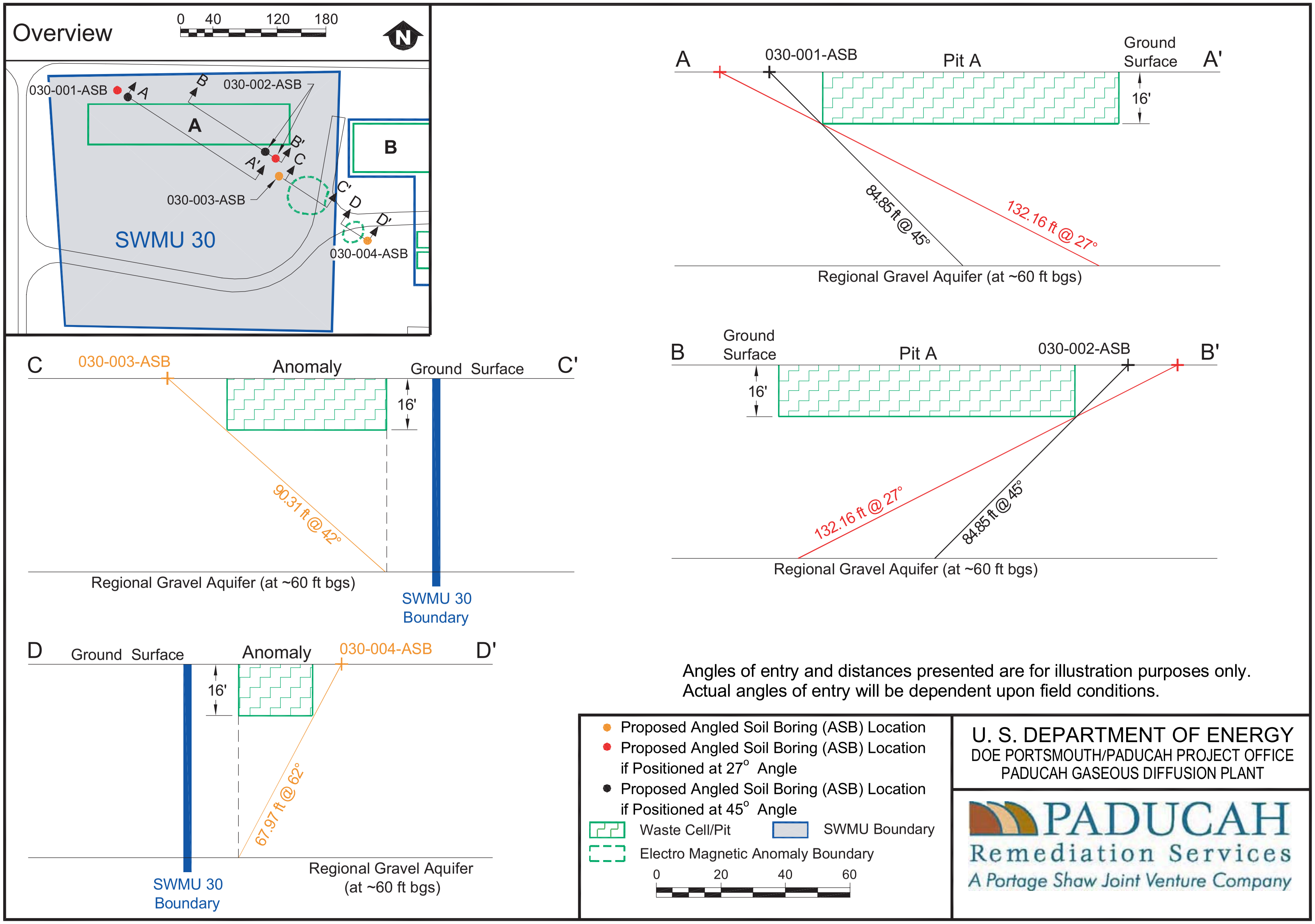


Figure 9.5. SWMU 30 BGOU RI/FS Proposed Sampling Locations

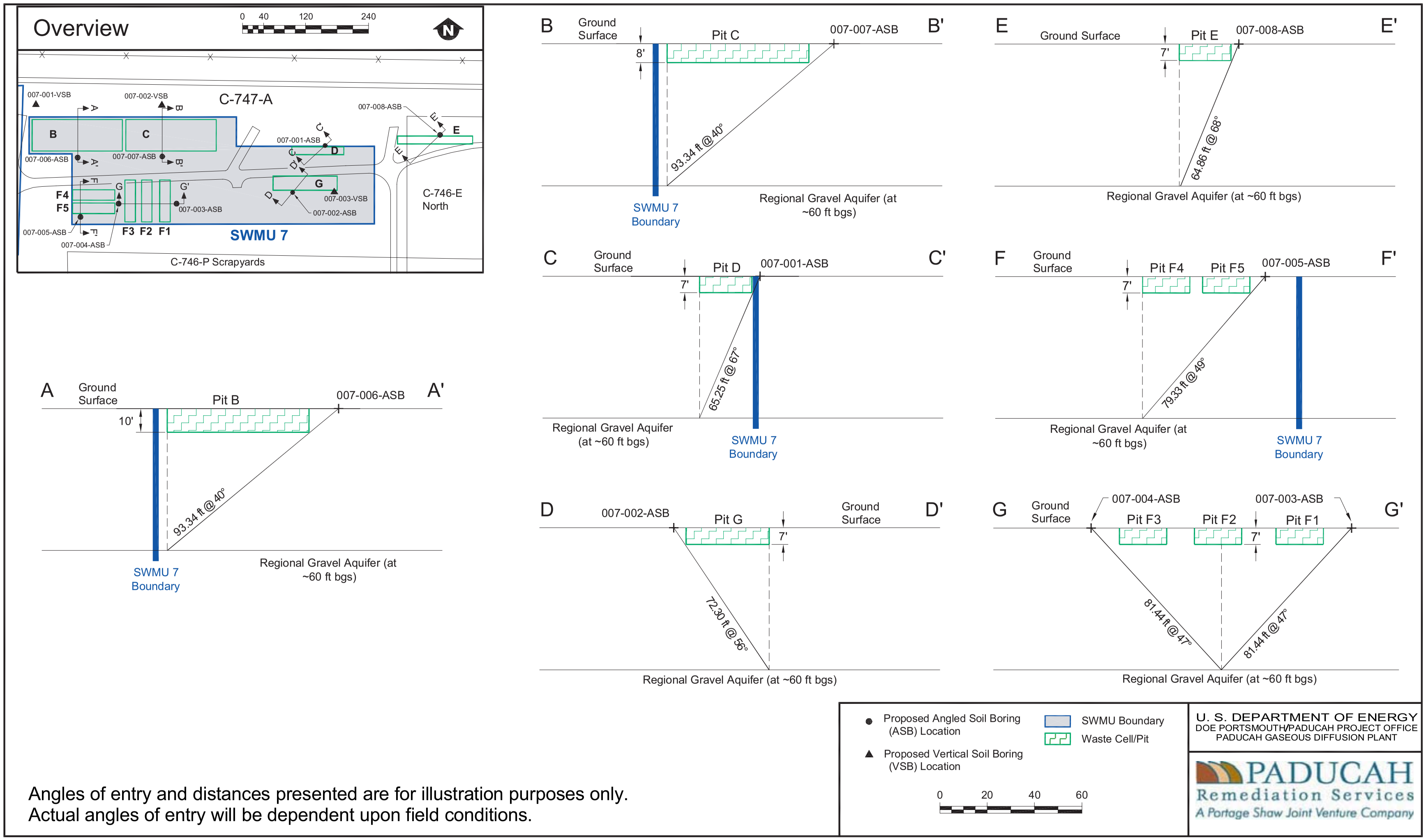


Figure 9.6. SWMU 7 BGOU RI/FS Proposed Sampling Locations

A terrain conductivity survey will be conducted using a Geonics EM-61 (or equivalent) that is capable of detecting objects to a depth of 20 ft bgs. This technique is preferred; however, fencing present in a portion of the site may cause excessive interference. If results are inconclusive following the terrain conductivity survey, magnetometer and/or GPR will be used in an attempt to define the extent of the burial pits. GPR is preferred because the magnetometer also may be affected by fencing. To prepare the site for the geophysical survey, a 20-ft by 20-ft grid will be established across the site. Grid spacing in areas where anomalous measurements are recorded will be reduced to a 10-ft interval or less to further delineate boundaries of the anomaly. Grid spacing was selected based on the shortest dimension of the smallest anomaly (approximately 20–25 ft) previously identified at the site.

Soil Boring Locations. Twelve angle soil borings will be drilled under the burial cells to collect soils from beneath the waste disposal cells. The final determination for exact placement of these borings will be made by DOE or DOE's Prime Contractor after an evaluation of the surface geophysical survey. The angle borings will be located as close to identified anomalies as possible, maximizing the extent of penetration under the buried wastes. Three vertical borings will be drilled in areas of potential or identified contamination where there is no burial cell located. Two borings are proposed north of SWMU 7 and one is in the area where the former "Drum Mountain" was located. Samples will be analyzed for parameters shown in Table 9.8.

Table 9.8 SWMUs 7 and 30 Soil Analyte and Method Detection List

Reporting Limit (µg/kg)	TCL volatiles SW-846, 8260		
10	Benzene	1,1-Dichloroethane	Tetrachloroethene
	Bromodichloromethane	1,2-Dichloroethane	Toluene
	Bromoform	1,1-Dichlorethene	trans-1,2-Dichloropropene
	Carbon disulfide	cis-1,2-Dichloroethene	trans-1,4-Dichloro-2-butene (100)
	Carbon tetrachloride	1,2-Dichloropropane	
	Chlorobenzene	Ethyl methacrylate	1,1,1-Trichloroethane
	Chloroform	Ethyl benzene	1,1,2-Trichloroethane
	cis-1,3-Dichloroprene	Iodomethane	Trichloroethene
	trans-1,3-Dichloropropene	Methylene chloride	Trichlorofluoromethane
	cis-1,3-Dichloropropene	Styrene	1,2,3-Trichloropropane
	Dibromochloromethane	Dichlorodifluoromethane	trans-1,2 Dichloroethene
	Dibromomethane	1,1,2,2-Tetrachoroethane	*m,p-* xylene (20 ug/kg)
	1,2-Dibromomethane	1,1,1,2-Tetrachloroethane	*o-* xylene
	Bromomethane	2-Chloroethyl vinyl ether	Chloromethane
	Chloroethane	2-Butanone	Vinyl chloride
	4-Methyl-2-pentanone	Acrolein	Vinyl acetate
	Acetone	Acrylonitrile	2-Hexanone

Table 9.8 SWMUs 7 and 30 Soil Analyte and Method Detection List (continued)

Reporting Limit (µg/kg)	TCL semivolatiles SW-846, 8270		
660	Acenapthene	Dibenzo(a,h)anthracene	Isophorone
	Acenaphthylene	Dibenzofuran	2-Methylnaphthalene
	Anthracene	1,2-Dichlorobenzene	2-Methylphenol (o-cresol)
	Benzo(a)anthracene	1,3-Dichlorobenzene	4-Methylphenol (p-cresol)
	Benzo(b)fluoranthene	1,4-Dichlorobenzene	Naphthalene
	Benzo(k)fluoroanthene	2,4-Dichlorophenol	Nitrobenzene
	Benzo(a)pyrene	Diethylphthalate	2-Nitrophenol
	Benzo(g,h,i)perylene	2,4-Dimethylphenol	N-Nitroso-di-n-dipropylamine
	bis(2-Chloroisopropyl)ether	Dimethylphthalate	
	bis(2-Chloroethoxy)methane	2,4-Dinitrotoluene	N-Nitrosodiphenylamine
	bis(2-Chloroethyl)ether	2,6-Dinitrotoluene	Phenanthrene
	bis(2-Ethylhexyl)phthalate	Fluoranthene	Phenol
	4-Bromophenyl-phenylether	Fluorene	Pyrene
	Butylbenzylphthalate	Hexachlorobenzene	1,2,4-Trichlorobenzene
	2-Chloronaphthalene	Hexachlorobutadiene	2,4,5-Trichlorophenol
	2-Chlorophenol	Hexachlorocyclopentadiene	2,4,6-Trichlorophenol
	di-N-butylphthalate	Hexachlorethane	4-Chlorophenyl-phenylether
	di-N-octylphthalate	Indeno(1,2,3-cd)pyrene	Chrysene
1300	Benzyl alcohol	4-Chloroanaline	3,3-Dichlorobenzidine
	4-Chloro-3-methylphenol		
3300	Benzoic acid	2-Nitroanaline	4-Nitrophenol
	4,6-Dinitro-2-methylphenol	3-Nitroanaline	Pentachlorophenol
	2,4-Dinitrophenol	4-Nitroanaline	
Reporting Limit (mg/kg)	**TCL PCBs SW-846, 8082**		
0.1	Aroclor-1016	Aroclor-1242	Aroclor-1254
	Aroclor-1221	Aroclor-1248	Aroclor-1260
	Aroclor-1232		
Reporting Limit (pCi/g)	**Radionuclides**		**Method**
5	Gross alpha		EPA-900
5	Gross beta		EPA-900
3	Uranium-234		Alpha Spec
2	Uranium-235		Alpha Spec
2	Uranium-238		Alpha Spec
8	Technetium-99		Liquid Scintillation
3	Thorium-228		Alpha Spec
4	Thorium-230		Alpha Spec
3	Thorium-232		Alpha Spec
3	Neptunium-237		Alpha Spec
6	Plutonium-238		Alpha Spec
4	Plutonium-239/240		Alpha Spec
3	Americium-241		Alpha Spec
0.5	Cesium-137		Gamma Spec

Table 9.8 SWMUs 7 and 30 Soil Analyte and Method Detection List (continued)

Reporting Limit (mg/kg)	Metals	Method
20	Aluminum	6010
10	Antimony	6010
2.5	Barium	6010
0.5	Beryllium	6010
2	Cadmium	6010
100	Calcium	6010
2.5	Chromium	6010
2.5	Cobalt	6010
2.5	Copper	6010
20	Iron	6010
20	Lead	6010
5	Magnesium	6010
2.5	Manganese	6010
5	Molybdenum	6010
5	Nickel	6010
2.5	Silver	6010
200	Sodium	6010
2	Thallium	6020
1	Uranium	6010
2.5	Vanadium	6010
20	Zinc	6010
1	Arsenic	6020
20	Selenium	6010
0.02	Mercury	7471

TCL = Target Compound List

An attempt also will be made to collect UCRS groundwater samples from angle borings, depending on the presence of groundwater. Groundwater samples will be collected from vertical borings from multiple discrete depths within the UCRS and RGA. Water sampling in the UCRS will be dictated by the presence of water-bearing zones—typically one or two samples will be collected using a hydro-punch advanced ahead of the augers. Water sampling in the RGA will begin at the top of the RGA (approximately 60 ft bgs) and continue at 10 ft intervals to the base of the RGA (approximately 100 ft bgs). This strategy will result in a total of two to six water samples collected from each boring, depending on the presence of water-bearing zones in the UCRS and the thickness of the RGA present in the boring.

Groundwater sample aliquots will be collected and analyzed for the parameters listed in Table 9.9.

Table 9.9 SWMUs 7 and 30 Groundwater Analyte and Method Detection List

Reporting Limit (µg/L)		TCL volatiles SW-846, 8260	
5	Benzene Bromodichloromethane Bromoform Carbon disulfide Carbon tetrachloride Chlorobenzene Chloroform cis-1,3-Dichloroprene trans-1,3-Dichloropropene cis-1,3-Dichloropropene Dibromochloromethane Dibromomethane 1,2-Dibromomethane Dichlorodifluoromethane	1,1-Dichloroethane 1,2-Dichloroethane 1,1-Dichlorethene cis-1,2-Dichloroethene 1,2-Dichloropropane Ethyl methacrylate Ethyl benzene Iodomethane Methylene chloride Styrene 1,1,2,2-Tetrachoroethane 1,1,1,2-Tetrachloroethane	Tetrachloroethene Toluene trans-1,2-Dichloropropene trans-1,4-Dichloro-2-butene (100) 1,1,1-Trichloroethane 1,1,2-Trichloroethane Trichloroethene Trichlorofluoromethane 1,2,3-Trichloropropane trans-1,2 Dichloroethene *m,p-* xylene (20 ug/L) *o-* xylene Vinyl chloride (2 ug/L)
10	Bromomethane Chloroethane	2-Chloroethyl vinyl ether	Chloromethane
50	2-Hexanone	4-Methyl-2-pentanone	Vinyl acetate
100	Acetone Acrolein	2-Butanone Acrylonitrile	
Reporting Limit (µg/L)		**TCL semivolatiles SW-846, 8270**	
10	Acenapthene Acenaphthylene Anthracene Benzo(a)anthracene Benzo(b)fluoranthene Benzo(k)fluoroanthene Benzo(a)pyrene Benzo(g,h,i)perylene bis(2-Chloroisopropyl)ether bis(2-Chloroethoxy)methane bis(2-Chloroethyl)ether bis(2-Ethylhexyl)phthalate 4-Bromophenyl-phenylether Butylbenzylphthalate 2-Chloronaphthalene 2-Chlorophenol di-N-butylphthalate di-N-octylphthalate	Dibenzo(a,h)anthracene Dibenzofuran 1,2-Dichlorobenzene 1,3-Dichlorobenzene 1,4-Dichlorobenzene 2,4-Dichlorophenol Diethylphthalate 2,4-Dimethylphenol Dimethylphthalate 2,4-Dinitrotoluene 2,6-Dinitrotoluene Fluoranthene Fluorene Hexachlorobenzene Hexachlorobutadiene Hexachlorocyclopentadiene Hexachlorethane Indeno(1,2,3-cd)pyrene	Isophorone 2-Methylnaphthalene 2-Methylphenol (o-cresol) 4-Methylphenol (p-cresol) Naphthalene Nitrobenzene 2-Nitrophenol N-Nitroso-di-n-dipropylamine N-Nitrosodiphenylamine Phenanthrene Phenol Pyrene 1,2,4-Trichlorobenzene 2,4,5-Trichlorophenol 2,4,6-Trichlorophenol 4-Chlorophenyl-phenylether Chrysene
20	Benzyl alcohol 4-Chloro-3-methylphenol	4-Chloroanaline	3,3-Dichlorobenzidine
50	Benzoic acid 4,6-Dinitro-2-methylphenol 2,4-Dinitrophenol	2-Nitroanaline 3-Nitroanaline 4-Nitroanaline	4-Nitrophenol Pentachlorophenol

Table 9.9 SWMUs 7 and 30 Groundwater Analyte and Method Detection List (continued)

Reporting Limit (µg/L)	TCL PCBs SW-846, 8082		
0.1	Aroclor-1016	Aroclor-1242	Aroclor-1254
	Aroclor-1221	Aroclor-1248	Aroclor-1260
	Aroclor-1232		
Reporting Limit (pCi/L)	**Radionuclides**		**Method**
3	Gross alpha		EPA-900
3	Gross beta		EPA-900
0.4	Uranium-234 (Filtered and Unfiltered)		Alpha Spec
0.4	Uranium-235 (Filtered and Unfiltered)		Alpha Spec
0.4	Uranium-238 (Filtered and Unfiltered)		Alpha Spec
1	Technetium-99		Liquid Scintillation
0.4	Thorium-228		Alpha Spec
0.4	Thorium-230		Alpha Spec
0.4	Thorium-232		Alpha Spec
0.5	Neptunium-237		Alpha Spec
0.4	Plutonium-238		Alpha Spec
0.4	Plutonium-239/240		Alpha Spec
0.4	Americium-241		Alpha Spec
0.4	Cesium-137		Gamma Spec
Reporting Limit (mg/L)	**Metals (Filtered and Unfiltered)**		**Method**
0.2	Aluminum		6010
0.005	Antimony		6010
0.01	Barium		6010
0.005	Beryllium		6010
0.0006	Cadmium		6010
5	Calcium		6010
0.01	Chromium		6010
0.01	Cobalt		6010
0.025	Copper		6010
0.05	Iron		6010
0.0013	Lead		6010
0.5	Magnesium		6010
0.01	Manganese		6010
0.001	Molybdenum		6010
0.04	Nickel		6010
0.01	Silver		6010
0.5	Sodium		6010
0.002	Thallium		6010
0.001	Uranium		6010
0.02	Vanadium		6010
0.02	Zinc		6010
0.001	Arsenic		6020
0.04	Selenium		6010
0.00001	Mercury		7471

TCL = Target Compound List

9.3.7 SWMU 145

SWMU 145	**Data Gaps:** There is no information on potential subsurface soil contamination directly beneath the burial pits. The potential for additional contaminants (other than what have been identified in previous investigations) seeping from the bottom of the burial cell is unknown. The potential that the soils immediately beneath the burial pits may have become contaminated and are now a secondary contaminant source is unknown. The exact location of burial cells within the SWMU is unknown. **Sampling Strategy:** Conduct a geophysical survey to determine the pit boundaries where uncertainties have been identified Drill seven angle borings and collect soil samples and UCRS groundwater samples (if sufficient amount of groundwater is available). If geophysical survey does not determine appropriate pits to angle beneath, then angle and boring location may be placed so as not to endanger the environment or the safety of the workers.

Aerial photographs dating to the 1950s, and other historical data, generally delineate the outlines of the SWMU 145 burial cell. The cell is bounded to the south and to the west by preexisting roads. The aerial photographs indicate the extent of clearing associated with disposal operations to the north and east.

Sampling activities during the late 1990s identified PGDP plant waste material at or near the surface in the southwest corner of this SWMU. Subsequent radiological scans of this material determined that it was radiologically contaminated. This area (approximately 200 ft^2) was covered and roped off to prevent exposure.

9.3.7.1 Data gaps

All boring information is from vertical borings that have been drilled beside or along the edges of the site.

- There is no information on potential subsurface soil contamination directly beneath the burial pits.
- The potential is unknown for additional contaminants (other than what have been identified in previous investigations) seeping from the bottom of the burial cell.
- The potential is unknown that the soils immediately beneath the burial pits may have become contaminated and are now a secondary contaminant source.
- The exact location of burial cells within the SWMU is unknown.

9.3.7.2 Sampling plan

The sampling approach has been designed to evaluate whether there have been releases from the bottom of the burial cells at SWMU 145, to characterize the nature and extent of the contamination in the subsurface soils and groundwater if there have been releases and whether these releases are contributing to TCE contamination in the RGA, and to identify any other areas of surface radiological contamination.

The following paragraphs outline the sampling and analytical requirements for SWMU 145 and summarize the rationale for the locations selected. Figure 9.7 shows the proposed sampling locations for this SWMU.

Surface Geophysical Survey. The exact boundaries of the burial pits are not defined, so a surface geophysical survey will be conducted along the northern and eastern boundaries to identify the burial areas. Several methods are proposed, because site-specific properties (e.g., fences, utilities, etc.) can interfere with the instruments. Three types of instruments (terrain conductivity meter, magnetometer, and GPR) will be available on-site to provide information about any anomalies present.

A terrain conductivity survey will be conducted using a Geonics EM-61 (or equivalent) that is capable of detecting objects to a depth of 20 ft bgs. This technique is preferred; however, fencing present in a portion of the site may cause excessive interference. If results are inconclusive following the terrain conductivity survey, either magnetometer and/or GPR will be used in an attempt to define the extent of the burial pits. GPR is preferred, because the magnetometer also may be affected by fencing. To prepare the site for the geophysical survey, a 4 to 5 ft grid will be established.

Soil Boring Locations. Seven angle soil borings will be drilled around the perimeter of the waste disposal cells to collect soils from beneath the waste disposal cells. The final determination for exact placement of these borings will be made after an evaluation of the surface geophysical data. The angle borings will be located as close to identified anomalies as possible, maximizing the extent of penetration under the buried wastes. Samples will be analyzed for the parameters shown in Table 9.10.

Table 9.10 SWMU 145 Soil Analyte and Method Detection List

Reporting Limit (µg/kg)	TCL volatiles SW-846, 8260		
10	Benzene	1,1-Dichloroethane	Tetrachloroethene
	Bromodichloromethane	1,2-Dichloroethane	Toluene
	Bromoform	1,1-Dichlorethene	trans-1,2-Dichloropropene
	Carbon disulfide	cis-1,2-Dichloroethene	trans-1,4-Dichloro-2-butene
	Carbon tetrachloride	1,2-Dichloropropane	1,1,1-Trichloroethane
	Chlorobenzene	Ethyl methacrylate	1,1,2-Trichloroethane
	Chloroform	Ethyl benzene	Trichloroethene
	cis-1,3-Dichloroprene	Iodomethane	Trichlorofluoromethane
	trans-1,3-Dichloropropene	Methylene chloride	1,2,3-Trichloropropane
	cis-1,3-Dichloropropene	Styrene	trans-1,2 Dichloroethene
	Dibromochloromethane	Dichlorodifluoromethane	*m,p-* xylene (20 ug/kg)
	Dibromomethane	1,1,2,2-Tetrachoroethane	*o-* xylene
	1,2-Dibromomethane	1,1,1,2-Tetrachloroethane	Chloromethane
	Bromomethane	2-Chloroethyl vinyl ether	Vinyl chloride
	Chloroethane	2-Butanone	Vinyl acetate
	4-Methyl-2-pentanone	Acrolein	2-Hexanone
	Acetone	Acrylonitrile	

Table 9.10 SWMU 145 Soil Analyte and Method Detection List (continued)

Reporting Limit (pCi/g)	Radionuclides	Method
5	Gross alpha	EPA-900
5	Gross beta	EPA-900
3	Uranium-234	Alpha Spec
2	Uranium-235	Alpha Spec
2	Uranium-238	Alpha Spec
8	Technetium-99	Liquid Scintillation
3	Thorium-228	Alpha Spec
4	Thorium-230	Alpha Spec
3	Thorium-232	Alpha Spec
3	Neptunium-237	Alpha Spec
6	Plutonium-238	Alpha Spec
4	Plutonium-239/240	Alpha Spec
3	Americium-241	Alpha Spec
0.5	Cesium-137	Gamma Spec
Reporting Limit (mg/kg)	**Metals**	**Method**
20	Aluminum	6010
10	Antimony	6010
2.5	Barium	6010
0.5	Beryllium	6010
2	Cadmium	6010
100	Calcium	6010
2.5	Chromium	6010
2.5	Cobalt	6010
2.5	Copper	6010
20	Iron	6010
20	Lead	6010
5	Magnesium	6010
2.5	Manganese	6010
5	Molybdenum	6010
5	Nickel	6010
2.5	Silver	6010
200	Sodium	6010
2	Thallium	6020
1	Uranium	6010
2.5	Vanadium	6010
20	Zinc	6010
1	Arsenic	6020
20	Selenium	6010
0.02	Mercury	7471

TCL = Target Compound List

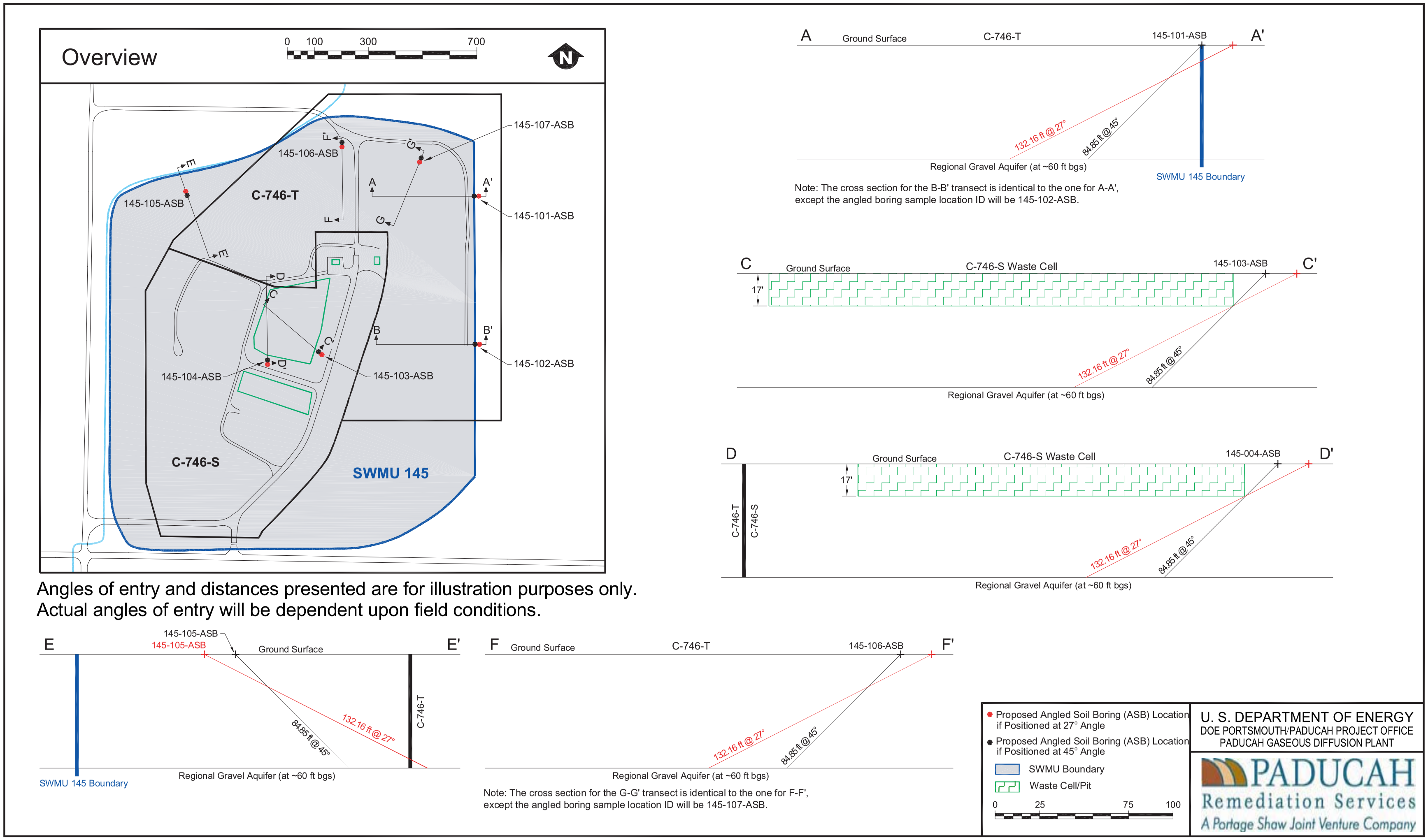


Figure 9.7. SWMU 145 BGOU RI/FS Proposed Sampling Locations

An attempt also will be made to collect UCRS groundwater samples from each angle boring, depending on the presence of groundwater. Groundwater sample aliquots will be collected and analyzed for the parameters listed in Table 9.11.

Table 9.11 SWMU 145 Groundwater Analyte and Method Detection List

Reporting Limit (µg/L)	**TCL volatiles SW-846, 8260**		
5	Benzene Bromodichloromethane Bromoform Carbon disulfide Carbon tetrachloride Chlorobenzene Chloroform cis-1,3-Dichloroprene trans-1,3-Dichloropropene cis-1,3-Dichloropropene Dibromochloromethane Dibromomethane 1,2-Dibromomethane Dichlorodifluoromethane	1,1-Dichloroethane 1,2-Dichloroethane 1,1-Dichlorethene cis-1,2-Dichloroethene 1,2-Dichloropropane Ethyl methacrylate Ethyl benzene Iodomethane Methylene chloride Styrene 1,1,2,2-Tetrachoroethane 1,1,1,2-Tetrachloroethane	Tetrachloroethene Toluene trans-1,2-Dichloropropene trans-1,4-Dichloro-2-butene 1,1,1-Trichloroethane 1,1,2-Trichloroethane Trichloroethene Trichlorofluoromethane 1,2,3-Trichloropropane trans-1,2 Dichloroethene *m,p-* xylene (20 ug/L) *o-* xylene Vinyl chloride (2 ug/L)
10	Bromomethane Chloroethane	2-Chloroethyl vinyl ether	Chloromethane
50	2-Hexanone	4-Methyl-2-pentanone	Vinyl acetate
100	Acetone Acrolein	2-Butanone Acrylonitrile	
Reporting Limit (pCi/L)	**Radionuclides**		**Method**
3	Gross alpha		EPA-900
3	Gross beta		EPA-900
0.4	Uranium-234 (Filtered and Unfiltered)		Alpha Spec
0.4	Uranium-235 (Filtered and Unfiltered)		Alpha Spec
0.4	Uranium-238 (Filtered and Unfiltered)		Alpha Spec
1	Technetium-99		Liquid Scintillation
0.4	Thorium-228		Alpha Spec
0.4	Thorium-230		Alpha Spec
0.4	Thorium-232		Alpha Spec
Reporting Limit (pCi/L)	**Radionuclides**		**Method**
0.5	Neptunium-237		Alpha Spec
0.4	Plutonium-238		Alpha Spec
0.4	Plutonium-239/240		Alpha Spec
0.4	Americium-241		Alpha Spec
0.4	Cesium-137		Gamma Spec

Table 9.11 SWMU 145 Groundwater Analyte and Method Detection List (continued)

Reporting Limit (mg/L)	Metals (Filtered and Unfiltered)	Method
0.2	Aluminum	6010
0.005	Antimony	6010
0.01	Barium	6010
0.005	Beryllium	6010
0.0006	Cadmium	6010
5	Calcium	6010
0.01	Chromium	6010
0.01	Cobalt	6010
0.025	Copper	6010
0.05	Iron	6010
0.0013	Lead	6010
0.5	Magnesium	6010
0.01	Manganese	6010
0.001	Molybdenum	6010
0.04	Nickel	6010
0.01	Silver	6010
0.5	Sodium	6010
0.002	Thallium	6010
0.001	Uranium	6010
0.02	Vanadium	6010
0.02	Zinc	6010
0.001	Arsenic	6020
0.04	Selenium	6010
0.00001	Mercury	7471

TCL = Target Compound List

9.4 SAMPLING PROCEDURES

Fieldwork and sampling at PGDP will be conducted in accordance with DOE Prime Contractor-approved medium-specific work instructions or procedures consistent with *Environmental Investigation Standard Operating Procedure and Quality Assurance Manual*, EPA Region 4, November 2001. DOE or its DOE Prime Contractor will approve any deviations from these work instructions and procedures. The DOE Prime Contractor will document changes on Field Change Request forms as detailed in the QAPP. Table 9.12 provides an example list of investigation activities that may require work instructions or procedures.

Table 9.12 Example Fieldwork and Sampling Activities Requiring Work Instructions or Procedures

Investigation Activity
Use of Field Logbooks
Lithologic Logging
Labeling, Packaging, and Shipping of Environmental Field Samples
Groundwater Sampling Procedures: Water Level Measurements
Monitoring Well Purging and Groundwater Sampling
Filter Pack and Screen Selection for Wells and Piezometers
Monitoring Well Installation
Monitoring Well Development
Field Measurement Procedures: pH, Temperature, and Conductivity, Dissolved Oxygen, and Eh (Oxidation Reduction Potential)
Sampling of Containerized Wastes
Opening Containerized Waste
On-Site Handling and Disposal of Waste Materials
Identification and Management of Waste Not From a Radioactive Material Management Area
Paducah Contractor Records Management Program
Quality Assured Data
Chain-of-Custody
Field Quality Control
Data Management Coordination Equipment Decontamination
Off-Site Decontamination Pad Operating Procedures
Cleaning and Decontaminating Sample Containers and Sampling Equipment
Environmental Radiological Screening
Pumping Liquid Wastes Into Tankers
Archival of Environmental Data Within the ER Program
Data Entry
Data Validation
Well and Temporary Boring Abandonment

9.5 DOCUMENTATION

Field documentation will be maintained throughout the BGOU RI/FS in various types of documents and formats, including the field logbooks, sample labels, sample tags, chain-of-custody forms, and field data sheets. The following general guidelines for maintaining field documentation will be implemented. Additional information is contained in the DMIP (Chapter 12). Documentation requirements are listed below. Entries will be written clearly and legibly using indelible ink.

- Corrections will be made by striking through the error with a single line that does not obliterate the original entry. Corrections will be dated and initialed.
- Dates and times will be recorded using the format "mm/dd/yy" for the date and the military (i.e., 24-hour) clock for the time.
- Zeroes will be recorded with a slash (/) to distinguish them from letter Os.
- Blank lines are prohibited. Information should be recorded on each line or a blank line should be lined out, initialed, and dated.
- No documents will be altered, destroyed, or discarded, even if they are illegible or contain inaccuracies that require correction.

- Information blocks on field data forms will be completed or a line will be drawn through the unused section, and the area will be dated and initialed.

- Unused logbook pages will be marked with a diagonal line drawn from corner to corner and a signature and date must be placed on the line.

- Security of logbooks will be maintained by storing them in a secured (e.g., locked) area when not in use.

- Photocopies of logbooks, field data sheets, and chain-of-custody forms will be made weekly and stored in the project file.

9.5.1 Field Logbooks

Field team personnel will use bound field logbooks with sequentially numbered pages for the maintenance of field records and for documenting any information pertinent to field activities. Field forms will be numbered sequentially or otherwise controlled. A designated field team member will record in the field logbooks sampling activities and information from site exploration and observation. Field documentation will conform to approved procedures for use of field logbooks. An integral component of QA/QC for the field activities will be the maintenance of accurate and complete field records and the collection of appropriate field data forms. The primary purpose of the logbook is to document each day's field activities; the personnel on each sampling team; and any administrative occurrences, conditions, or activities that may have affected the fieldwork or data quality of any environmental samples for any given day. The level of detail of the information recorded in the field logbook should be such that an accurate reconstruction of the field events can be created from the logbook. The project name, logbook number, client, contract number, task number, document control number, activity or site name, and the start and completion dates will be listed on each logbook's front cover. Important phone numbers, radio call numbers, emergency contacts, and a return address should be recorded on the inside of the front cover.

9.5.2 Sample Log Sheets

A sample log sheet will contain sample-specific information for each field sample collected, including field QC samples. Generally, sample log sheets will be preprinted from the data management system with the following information:

- Name of sampler;

- Project name and number;

- Sample identification number;

- Sampling location, station code, and description;

- Sample medium or media;

- Sample collection date;

- Sample collection device;

- Sample visual description;

- Collection procedure;

- Sample type;
- Analysis; and
- Preservative.

In addition, specific analytical requests will be preprinted from the data management system and will include the following for each analytical request:

- Analysis/method,
- Container type,
- Number of containers,
- Container volume,
- Preservative (type/volume), and
- Destination laboratory.

During sample collection, a field team member will record the remaining required information and will sign and date each sample log sheet. The following information will be recorded for each sample, whether or not the sample was collected:

- The date and time of collection;
- The name of the collector;
- Collection methods and/or procedures;
- Required field measurements and measurement units;
- Instrumentation documentation, including the date of last calibration;
- Adherence to, or deviation from, the procedure and the BGOU work plan;
- Weather conditions at the time of sample collection;
- Activities in the area that could impact subsequent data evaluation;
- General field observations that could assist in subsequent data evaluation;
- Lot number of the sample containers used during sample collection;
- Sample documentation and transportation information, including unique chain-of-custody form number, airbill number, and container lot number; and
- Relevant and associated field QC samples (for each sample).

If preprinted sample log sheets are not used, information will be recorded manually. A member of the field sampling team (other than the recorder) will perform a QA review of each sample log sheet and document the review by signing and dating the log sheet. Notations of deviations will be initialed by the FTM as part of his/her review of the logbook.

9.5.3 Field Data Sheets

Field data sheets will be maintained, as appropriate, for the following types of data:

- Water level measurements,
- Soil boring logs,
- MW construction logs,
- Sample log sheets,
- Well development logs,
- Well purging logs,
- Groundwater sampling logs,
- Chain-of-custody forms,
- Instrument calibration logs,
- Temperature monitoring sheets, and
- VOC concentrations and radiological values recorded for each sample collected.

Data to be recorded will include such information as the location, sampling depth, sampling station, and applicable sample analysis to be conducted. Field-generated data forms will be prepared, if necessary, based on the appropriate requirements. The same information may be included in the field logbook or, if not, the field logbook should reference the field data sheet. If preprinted field data sheets are not used, information will be recorded manually in the field logbook.

9.5.4 Sample Identification, Numbering, and Labeling

In addition to field logbooks and field data sheets, the sampling team will use labels to track sample holding times, to provide sample traceability, and to initiate the chain-of-custody record for the environmental samples. A pressure-sensitive gummed label (or equivalent) will be secured to each sample container at the time of collection, including duplicates and trip or field blanks, at or before the completion of sample collection.

Sample labels will be waterproof or will be sealed to the sample container with clear acetate tape after all information has been recorded on the label. Generally, sample labels will be preprinted with information from the data management system and will contain the following information:

- Station name,
- Sample identification number,
- Sample matrix,

- Sample type (grab or composite),
- Type or types of analysis required,
- Sample preservation (if required), and
- Destination laboratory.

A field sampling team member will complete the remaining information during sample collection, including these items:

- Date and time of collection, and
- Initials of sampler.

The sample numbers will be recorded in the field logbook along with the time of collection and descriptive information previously discussed.

9.5.5 Sample Chain-of-Custody

Chain-of-custody procedures will document sample possession from the time of collection, through transfers of custody, to receipt at the laboratory and subsequent analysis. Chain-of-custody records will accompany each packaged lot of samples; the laboratory will not analyze samples that are not accompanied by a correctly prepared chain-of-custody record. A sample will be considered under custody if it is (1) in the possession of the sampling team; (2) in view of the sampling team; or (3) transferred to a secured (i.e., locked) location. Chain-of-custody records will follow the requirements as specified in a DOE Prime Contractor-approved procedure for keeping records. This form will be used to collect and track samples from collection until transfer to the laboratory. Copies of the signed chain-of-custody records will be faxed or delivered to the DOE Prime Contractor SMO within three days of sample delivery.

The Sampling Team Leader is responsible for reviewing and confirming the accuracy and completeness of the chain-of-custody form and for the custody of samples in the field until they have been properly transferred to the Sample Coordinator. The Sample Coordinator is responsible for sample custody until the samples are properly packaged, documented, and released to a courier or directly to the analytical laboratory. If samples are not immediately transported to the analytical laboratory, they will remain in the custody of the Sample Coordinator, where they will be refrigerated and secured either by locking the refrigerator or by placing custody seals on the individual containers.

Each chain-of-custody form will be identified by a unique number located in the upper-right corner, and recorded on the sample log sheet at the time of sample collection. The laboratory chain-of-custody will be the "official" custody record for the samples. Each chain-of-custody form will contain the following information:

- The sample identification for each sample;
- Collection data for each sample;
- Number of containers of each sample;
- Description of each sample (i.e., environmental matrix/field QC type) and analyses required for each sample; and

- Blocks to be signed as custody is transferred from one individual to another.

The airbill number will be recorded on the chain-of-custody form, if applicable. The laboratory chain-of-custody form will be sealed in a resealable plastic bag and taped to the inside of the cooler lid if the samples are to be shipped off-site. A copy will be retained in the laboratory, and the original will be returned to the Sample Manager with the completed data packages.

At each point of transfer, the individuals relinquishing and receiving custody of the samples will sign in the appropriate blocks and record the date and time of transfer. When the laboratory sample custodian receives the samples, he or she will document receipt of the samples, record the time and date of receipt, and note the condition of the samples (e.g., cooler temperature, whether the seals are intact) in the comments section. The laboratory then will forward appropriate information to the Sample Manager. This information may include the following:

- A cover memo stating sample receipt date and any problems noted at the time of receipt; and
- A report showing the field sample identification number, the laboratory identification number, and the analyses scheduled by the laboratory for each sample.

9.5.6 Sample Shipment

Aliquots of investigative samples will be screened by an on-site laboratory before shipment to an off-site laboratory. Results from the screening process will be recorded in Paducah's Project Environmental Measurements System (PEMS) and will be reviewed prior to preparation for sample shipment off-site. Sample containers will be placed in the shipping container and packed with ice and absorbent packing for liquids. The completed chain-of-custody form will be placed inside the shipping container, unless otherwise noted. The container then will be sealed. In general, sample containers will be packed according to the following procedures:

- Glass sample containers will be wrapped in plastic insulating material to prevent contact with other sample containers or the inner walls of the container.
- Logbook entries, sample tags and labels, and chain-of-custody forms will be completed with sample data collection information and names of persons handling the sample in the field before packaging.
- Samples, temperature blanks, and trip blanks will be placed in a thermal-insulated cooler along with ice that is packed in resealable plastic bags. After the cooler is filled, the appropriate chain-of-custody form will be placed in the cooler in a resealable plastic bag attached to the inside of the cooler lid.
- Samples will be classified according to U.S. Department of Transportation (DOT) regulations pursuant to 49 CFR 173. All samples will be screened for radioactivity to determine that DOT limits of 2.0 nCi/mL for liquid waste and 2.0 nCi/g for solid waste are not exceeded.

9.5.7 Field Planning Meeting

A field planning meeting will occur before work begins at the site, so that all involved personnel will be informed of the requirements of the fieldwork associated with the project. Additional planning meetings will be held whenever new personnel join the field team or if the scope of work changes significantly. Each meeting will have a written agenda and attendees must sign an attendance sheet, which will be maintained on-site and in the project files. The following example topics will be discussed at these meetings:

- Project- and site-specific health and safety, objectives and scope of the fieldwork, equipment and training requirements;
- Procedures;
- Required QC measures; and
- Documents covering on-site fieldwork.

9.5.8 Readiness Checklist

Before implementation of the field program, project personnel will review the work control documents to identify field activities and materials required to complete the activities, including the following items:

- Task deliverables,
- Required approvals and permits,
- Personnel availability,
- Training,
- Field equipment,
- Sampling equipment,
- Site facilities and equipment, and
- Health and safety equipment.

Before fieldwork begins, appropriate DOE Prime Contractor personnel will concur that readiness has been achieved.

9.6 SAMPLE LOCATION SURVEY

Surveying of sampling locations will be conducted upon completion of RI/FS field activities. Where possible, temporary markers consisting of flagging or of wooden or metal stakes will be used to mark boring locations. Brass markers will be incorporated as part of pad installation for any MWs; however, a thorough description of each location will be made during field sampling activities and will be documented using field maps. This documentation will be used for the survey effort if permanent sampling location markers are disturbed or if permanent markers cannot be placed at the time of sampling. A member of the field sampling crew will accompany the survey crew to provide information regarding the location of sampling points. Each sample point will be surveyed for its horizontal and vertical location using the PGDP coordinate system for horizontal control. Additionally, State Plane Coordinates will be provided using the U.S. Coast and Geodetic Survey North American Datum of 1983. The datum for vertical control will be the U.S. Coast and Geodetic Survey North American Vertical Datum of 1988. Accuracy for this work will be that of a Class 1 First Order survey. Work will be performed by or under responsible charge of a Professional Land Surveyor registered in the Commonwealth of Kentucky. Coordinates will be entered into Paducah PEMS and will be transferred with the station's ready-to-load (RTL) file to Paducah OREIS.

10. HEALTH AND SAFETY PLAN

This ES&H Plan has been developed for the PGDP BGOU RI/FS Work Plan. This ES&H Plan establishes the specific applicable standards and practices to be used during execution of the BGOU Site Investigation to protect the safety and health of workers, the public, and the environment. This document contains information about the sites, potential contaminants and hazards that may be encountered on-site, and hazards inherent in routine procedures. The list of contaminants is site-specific and based on previous investigations.

This ES&H Plan is designed to accommodate anticipated contingencies. This ES&H Plan will evolve as lessons learned are incorporated to continuously improve work processes, while maintaining focus on the functions and guiding principles of ISMS and the zero-accident performance philosophy.

This work will be performed in accordance with the DOE's ISMS and its Environmental Compliance and Health and Safety policy statement; these establish a goal of zero-accident performance. Hazard controls will include access restrictions, operator-training requirements, exclusion of nonessential personnel from the work zone, use of personal protective equipment (PPE), and other relevant controls.

10.1 INTEGRATED SAFETY MANAGEMENT SYSTEM

This project will pursue the DOE's goal of zero-accident performance through project-specific implementation of ISMS. The core functions and guiding principles of ISMS will be implemented by incorporating applicable programs, policies, technical specifications, and procedures from DOE, Occupational Safety and Health Administration (OSHA), project team, and other applicable regulatory guidance. A brief description of the five ISMS core functions is provided below.

10.1.1 Define Scope of Work

Defining and understanding the scope of work is the first critical step in successfully performing any specific activity in a safe manner. Each member of the BGOU RI/FS Work Plan implementation project team will participate in discussions conducted to understand the scope and contribute to the planning of the work. The project team may conduct a project team-planning meeting to discuss the team's general understanding of the scope and the technical and safety issues involved. This meeting is conducted to ensure all parities are in agreement on the scope and general approach to complete the scope.

10.1.2 Analyze Hazards

In the course of planning the work, the project team will identify hazards associated with the performance of the work. Hazards may be identified and assessed by performing a site visit; reviewing lessons learned; reviewing project plans, and developing the project-specific documentation such as the ES&H crosswalk.

Once the hazards have been identified and assessed, measures will be identified to minimize risks to workers, the public, and the environment. These measures are described in the project-specific activity hazard analyses (AHAs), which serve to provide a control mechanism for all work activities. AHAs are detailed, activity-specific evaluations that address each step of the task and/or activity that will be performed. The AHA development process entails a detailed evaluation of each task to identify specific activities or operations that will be required to successfully complete the scope of work and defines the potential chemical, physical, radiological, and/or biological hazards that may be encountered; the media and manner in which they may occur; and how they are to be recognized, mitigated, and controlled. Appropriate hazard controls may include engineering controls, administrative controls, and the use of PPE. AHAs also will include available historical information for the site or the specific work areas and historical data describing contaminants of concern. This approach has been developed to be consistent with the requirements in OSHA regulations for Health and Safety Plans for Hazardous Waste Operations and Emergency Response (29 CFR 1910.120 and 1926.65). The project team is responsible for the preparation, revision, and implementation of all AHAs.

All AHAs will be submitted for review and comment before the start of any activities covered under the applicable AHA. The ES&H Representative will review all AHAs with the personnel who will perform the work. Participants in this review will sign and date the AHA to signify they understand all hazards, preventative measures, and requirements in the AHA. A copy of the AHA with appropriate signatures shall be maintained at the work location.

10.1.3 Develop and Implement Hazards Controls

The primary mechanisms used to flow down ISMS controls to the project team are subcontract requirements, work smart standards, program plans, project-specific plans, and technical standard operating procedures. Other mechanisms may include corporate policies and procedures, program/project management systems, employee ES&H training, communication, work site inspections, independent assessments, and audits. Specific actions that will be taken by the project team to ensure that controls are in place include the following:

- Kickoff meeting,
- Pre-job training,
- Site access,
- Medical monitoring,
- Procurement and testing of monitoring equipment,
- Permits,
- Setup emergency response and communication system,
- Setup field project files,
- Hazard communications (HAZCOM), and
- Readiness review.

A project-specific pre-job training session will be completed after the AHAs have been developed, reviewed, revised, and approved. This session will be facilitated by the RI Project Manager, ES&H Representative, FTM, QA Specialist, and the WMC. The training will include a thorough review of the scope of work to be performed, the contents of the AHAs, and any project-specific information necessary to supplement the ES&H plan. In developing the content for this training and its presentation to the project team, the ES&H Representative will work with the RI Project Manager to solicit input from employees so that the training is tailored to relevant issues and concerns. All personnel who will be conducting site activities, including subcontractors, will be required to participate in this training. As part of that training, employee involvement will be emphasized and encouraged in all phases of the planned work. A record of attendance will be documented and provided when requested. The project team also will hold a monthly safety meeting at the work site (in addition to daily tailgate safety meetings) for all employees involved in the work. This meeting provides the opportunity to discuss safety issues, lessons learned, and other pertinent issues.

The pre-job briefing also incorporates the principles of ISMS. The specific steps within ISMS are emphasized to each employee. It is emphasized that no employees will be directed or forced to perform any task that they believe is unsafe, puts their health at risk, or that could endanger the public or the environment. One of the key elements of this ES&H plan is that all personnel have "stop work authority" and are encouraged to use this authority when they perceive the safety of workers or the public to be at risk.

Employee involvement is emphasized in all pre-job training sessions beginning with initial orientation training and then periodically being reinforced in refresher training, as applicable, and in ES&H briefings/meetings. Whenever possible, employees are involved in the selection, development, and presentation of training topics, and their full and constructive input is encouraged in all communication sessions. The pre-job briefing will cover the required training curriculum mandated by DOE, OSHA, or other defined training requirements that are contained in the subcontract.

10.1.4 Perform Work Within Controls

After the readiness review has been completed and the project team has been given notice to proceed, the project-specific plans will be implemented. The RI Project Manager, FTM, and ES&H Representative will verify that all applicable plans, forms, and records are contained in the field project files to be kept on-site and accessible by all parties. Actions that will be taken during the performance of the work to incorporate these ISMS principles:

- Daily tailgate safety meetings,
- Monthly project safety meetings,
- ES&H oversight/inspections,
- Daily inspection of equipment, and
- Stop work authority.

Daily safety briefings (e.g., safety tailgate or toolbox meetings) will be conducted with all personnel participating, including subcontractor personnel. These sessions also will focus on fostering two-way communication, eliciting feedback, and reinforcing employee involvement.

ES&H personnel will perform both announced and unannounced ES&H oversight assessments, safety inspections, and/or audits of the project team's activities to verify compliance with the requirements of the subcontract and project plans. The ES&H Representative will participate in ES&H safety meetings in accordance with the schedule agreed upon in the subcontract.

Although line management holds the ultimate responsibility and accountability for ES&H matters, this does not, in any way, absolve individual employees from fulfilling their personal ES&H

responsibilities. Each project employee is responsible for his/her own health and safety, including performing his/her work in accordance with established requirements, complying with specified policies and procedures, performing his/her work in a manner that is consistent with training and communications received, and actively participating in the ES&H program to continuously improve its effectiveness.

The opportunity for employees to provide periodic feedback is provided during the daily tailgate safety briefing or the on-site monthly project safety meeting. The agenda for the monthly project safety meeting will include issues and topics relevant to site activities and those raised by project personnel. This meeting is documented and the signature of each attendee is obtained to acknowledge personal attendance.

10.1.5 Feedback/Improvement

Feedback and improvement is accomplished through several channels, including safety audits, self-assessments, employee suggestions, lessons learned, post-job briefings, and injury/illness reports. These actions will be used to solicit worker feedback, as well as to identify, address, and communicate lessons learned using standard corrective action planning and continuous improvement processes that are described in the QAPP.

The active and genuine involvement of employees will take many forms. Examples of typical project activities in which employee involvement is fostered include activity hazard identification, mitigation/control, and communication; selection and use of hazard controls (i.e., engineering controls, administrative controls, and PPE); and coaching or mentoring by other employees. A cornerstone of any effective ES&H program is the active involvement and participation of employees that it is designed to protect. An essential element of this is thorough communication and feedback throughout the organization, with an emphasis on identifying opportunities for continuous improvement of the program. The objective of active employee involvement in the ES&H program is to develop a culture in which employees feel empowered and take ownership of the program.

The ES&H Representative and the RI Project Manager will encourage employees to freely submit suggestions that offer opportunities for improvement.

At the conclusion of fieldwork, a post-job briefing will be conducted to allow project personnel to communicate:

- Lessons learned,
- How work steps/procedures could be modified to promote a safer working environment,
- How communications could be improved within the project team,
- Issues or concerns they may have regarding how the work was performed, and
- Any other topics relevant to the work performed.

10.2 KEY ENVIRONMENT, SAFETY, AND HEALTH RESPONSIBILITIES

10.2.1 RI Project Manager

The RI Project Manager has overall responsibility and authority to direct technical, management, cost, and contractual matters related to the project. The RI Project Manager ultimately is responsible for the safety and health of employees performing project-associated activities on the site.

Specific responsibilities of the RI Project Manager will include, but not be limited to, the following:

- Ensures that project work conducted by subcontractors is conducted safely.
- Serves as primary point of contact.
- Identifies required ES&H needs and ensures that project personnel are trained in requirements.
- Implements and enforces the ES&H plan, the AHAs, and other addenda.
- Consults on safety-related matters with the Site Supervisors, the ES&H Manager, and the ES&H Representative.
- Participates with the Site Supervisors, the ES&H Manager, and the ES&H Representative in investigations or disciplinary actions for violations of the ES&H plan.

10.2.2 Field Team Manager

The FTM will oversee the field activities associated with the project and will be responsible for overall execution of the field activities associated with the project. He or she is responsible for enforcing the field requirements of this plan. Specific responsibilities of the FTM are listed below.

- Enforces compliance with the project ES&H plan.
- Coordinates on-site operations, including subcontractor activities.
- Ensures that subcontractors follow the requirements of this ES&H plan.
- Coordinates and controls any emergency response actions.
- Ensures that at least one person currently certified in first aid/cardiopulmonary resuscitation (CPR) is on-site during site operations.
- Conducts or ensures worksite inspections.
- Conducts or ensures daily “tailgate” safety briefings.
- Maintains current copies of the project ES&H plan on-site.

10.2.3 Environment, Safety, and Health Representative

The ES&H Representative has the following responsibilities and authorities:

- During fieldwork, conducts daily (documented) ES&H inspections of contractor/subcontractor work activities and joint weekly inspections.

- Stops work and removes contractor/subcontractor personnel from the site if the safety or health of those personnel, other site personnel, or third parties is jeopardized by work activities.

- Verifies that all on-site personnel have the required training and certification and maintains copies of required documentation in on-site files.

- Provides project-specific training for new employees and visitors.

- Establishes and implements applicable ES&H procedures.

- Establishes and maintains systems to inform personnel on how to respond to emergency warning systems for the project (including evacuation alarms, accountability rosters, assembly points, etc.).

- During fieldwork activities, participates in plan-of-the-day meetings.

- Ensures that the first aid kits are kept current.

- Ensures that proper chemical and safety postings are in place and legible.

- Ensures that all operations are conducted so as to mitigate adverse environmental impacts (e.g., spill containment, erosion control).

- Establishes and maintains the hazard communication program [including material safety data sheets (MSDSs); employee training; maintenance of an inventory listing material; materials identification number; approximate quantity; and storage location].

- Designs personnel Industrial Hygiene monitoring strategies to include, but not limit to, personal air monitoring (breathing zone), ambient breathing zone monitoring, noise surveys, and heat stress monitoring.

- Performs personnel monitoring to evaluate existing and potential exposure to chemical, physical, biological, and radiological hazards.

- Interprets, reports, and takes appropriate actions indicated by personnel monitoring results.

- Evaluates the site for any hazards not identified in the AHA, initiates safety measures required to protect personnel, and revises documents accordingly.

- Establishes and maintains programs required to mitigate hazards identified in the AHA.

- Maintains first aid and OSHA 300 logs; reports accidents and injuries through the appropriate channels; and conducts accident/incident investigations as required, including the completion of appropriate forms.

- Coordinates with off-site emergency responders and medical service organizations to establish required services and verify that phone numbers, addresses, and contacts are current and accurate.

10.2.3 Environment, Safety, and Health Manager

The ES&H Manager has the following responsibilities:

- Reviews and approves all project ES&H plans.
- Oversees implementation of project ES&H plans and procedures.
- Conducts, or approves personnel to conduct, corporate ES&H surveillances and audits, and directs and mentors the ES&H Representative.
- Reviews Industrial Hygiene sampling strategy and resulting data.
- Reassesses sampling strategy and required PPE based on sample results.

10.3 REPORT/RECORD KEEPING

Project requirements include the following.

- All accidents and near misses must be reported to the ES&H Representative and the RI Project Manager immediately.
- The Supervisor's Accident Investigation Form must be completed for all accidents and near misses.
- Copies of training and medical certificates required for this project will be maintained on-site.
- Hours worked and accident experience will be recorded through the applicable contract.

10.4 MEDICAL SURVEILLANCE

The ES&H Representative will maintain copies of medical clearance forms on-site. Included with the medical clearances will be other training records including fit test records, 40-hour training certificates, 8-hour refresher certificates, supervisor certificates, etc. Each employee who is or may be exposed to hazardous substances or health hazards at or above the permissible exposure limit for 30 days or more per year, and each employee who wears a respirator for 30 days or more per year will receive a medical examination before assignment, approximately 12 months later, and at termination of employment or at reassignment. Employees who develop signs or symptoms indicating overexposure or are injured or exposed above the permissible exposure limit in an emergency situation will be examined medically as soon as possible following the incident.

10.5 FIRST AID AND MEDICAL SERVICES

Project requirements include all of the following:

- At least one person with current first aid training, CPR training, and bloodborne pathogen training will be on-site during all work activities.
- Only personnel with current first aid/CPR training will administer minor job-site first aid.

- The PGDP Medical Facility will be the primary resource for emergency medical care during this project.

- All job-related injuries or illnesses must be reported immediately to the ES&H Representative and the RI Project Manager. An accident investigation will be completed within 24 hours following the occurrence and submitted to management.

10.6 TRAINING

10.6.1 Hazardous Waste Worker Training

Site personnel, such as equipment operators and field technicians, will be required to have successfully completed the initial 40-hour Hazardous Waste Site Operations Training Program, including all required annual updates consisting of eight hours of refresher training, as well as, three days of on-the-job training under the direct supervision of a trained, experienced supervisor. Personnel occasionally on-site for a specific limited task who are unlikely to be exposed above the permissible exposure limit will be required to have successfully completed a minimum of 24 hours of initial training with one day of on-the-job training under the direct supervision of a trained, experienced supervisor. Site visitors (observers) will be restricted to the Support Zone unless documentation of training is presented.

10.6.2 First Aid/Cardiopulmonary Resuscitation

At least one individual trained in first aid/cardiopulmonary resuscitation will be assigned to activities being performed at hazardous and potentially hazardous waste sites.

10.6.3 On-Site Training

Before beginning field activities, all site personnel will attend a pre-entry briefing provided by the ES&H Representative. During this briefing the ES&H plan will be discussed, and personnel will become familiar with site conditions, zone boundaries, and health hazards. Follow-up safety discussions will be conducted and documented at the daily tool box safety meeting.

10.6.4 Subcontractor Training

All subcontractor employees must provide documentation for training that is pertinent and relevant for the tasks to be performed and necessary for compliance with local, state, or federal regulations. Additional training may be required as needed.

10.6.5 Site Specific Training

All personnel will be required to attend the following site-specific training:

- Security Orientation,

- General Employee Training (GET), and

- Radiological Worker II Training.

Additional training may be required as needed. This training may include (but not be limited to) the following:

- Trenching and Excavation,
- Lockout/Tagout, and
- Hoisting and Rigging Awareness.

10.7 ACTIVITY HAZARD ASSESSMENT

An AHA will be prepared for the major tasks planned for this project with the assistance of workers familiar with the type of tasks to be performed. If additional tasks are identified, the hazards and necessary controls will be determined and documented in a modified AHA. The AHA must be approved by the ES&H Manager or designee prior to initiating these tasks.

All workers will be trained on the AHA as it applies to their work. This training will be documented by signing the AHA. Following completion of an activity, employees will provide feedback, and "lessons learned" will be documented.

10.8 FACILITY/SITE ACCESS CONTROL

Work zones will be utilized to control access. These areas will be controlled by the appropriate subcontractor to minimize the number of individuals potentially exposed to site hazards and to ensure that individuals who enter follow the required procedures. The following is a description of the different types of zones that will be established at the site.

- Exclusion Zone (EZ)—The area where work is being performed and chemical, physical, and/or radiological hazards exist. Entry into this area is controlled and the area clearly marked with barrier tape, rope or flagging. Signage required by OSHA will be posted. Unauthorized entry into these areas is strictly prohibited. Permission to enter the EZ is granted by the ES&H Representative.

- Contamination Reduction Zone (CRZ)—The area between the EZ and the Construction Zone (CZ). It serves as a buffer to reduce the possibility of the Construction Zone becoming contaminated. It is also the area where decontamination of personnel and equipment is conducted. Entry into this area is controlled and the area clearly marked with barrier tape, rope or flagging. Signage required by OSHA will be posted.

- Construction Zone—The area outside of potential contamination, but still encompassing work activities and possible hazards associated with fieldwork activities. Entry into this area is controlled and the area clearly marked with barrier tape, rope or flagging. Signage required by OSHA will be posted.

- Support Area—The area immediately outside of the work zones. This area serves as an administrative area, a storage area for noncontaminated equipment, a break area, and an area for the consumption of food and beverages. This area does not require delineation by barricade tape/ropes.

10.9 HAZARD COMMUNICATION

OSHA's 29 CFR 1910.1200, "Hazard Communication Standard," states that all employees handling or using hazardous or potentially hazardous materials be advised and informed of the health hazards associated with those materials.

10.9.1 Material Safety Data Sheet

An MSDS provides specific material identification information; ingredients and hazards; physical data; fire and explosion information; reactivity data; health hazard information; spill, risk, and disposal procedures; special protection information; and special precautions required for materials manufactured for use. It is the manufacturer's responsibility to provide this information to the user for any materials that contain hazardous or potentially hazardous ingredients. Each employee is to be made aware that the MSDSs are available. The ES&H Representative shall maintain copies of all MSDSs for chemicals brought on-site and shall have them readily available.

10.9.2 Chemical Inventory

A list of all chemicals brought on-site will be maintained by the ES&H Representative. A Hazardous Material Inventory System (HMIS) Physical Inventory Form and MSDSs must be submitted to the Prime Contractor prior to delivery on-site, and monthly thereafter.

10.9.3 Labels

It is the responsibility of the ES&H Representative to ensure that all potentially hazardous materials taken to a project site are properly labeled [per 29 CFR 1910.1200 (f)] as to the contents of the container and with the appropriate hazard warnings (including target organs).

10.10 EMERGENCY MANAGEMENT

In the event of an emergency, all site personnel shall follow the requirements and provisions of the PGDP Emergency Management Plan. Emergency response shall be provided by the PGDP emergency response organization. The ES&H Representative will be in charge of personnel accountability during emergency activities. All personnel working on-site will be trained to recognize and report emergencies to the ES&H Representative or the FTM. The ES&H Representative or FTM will be responsible for notifying the PGDP emergency response organization.

The PGDP emergency response organization will be contacted for emergency response to all medical emergencies, fires, spills, or other emergencies. The Plant Shift Superintendent (PSS) will coordinate 24-hour emergency response coverage. The requirements of this section will be communicated to site workers. Any new hazards or changes in the plan also will be communicated to site workers.

10.10.1 Potential Emergencies

Potential emergencies that could be encountered during this project include, but are not limited to, fires, spills, and personnel exposure or injury. A local emergency manual, which contains explicit instructions and information about required emergency actions and procedures, is located near the entrances of each PGDP facility.

10.10.1.1 Fires

In SWMU 2, there is a potential for encountering pyrophoric uranium. Workers will be trained in the proper response protocol for fires involving uranium or an insoluble uranium compound.

In the event of a fire, the PSS shall be notified immediately. If it is safe to do so, and they are properly trained, on-site personnel may attempt to extinguish an incipient fire with the available fire extinguisher and isolate any nearby flammable materials. If there is any doubt about the safety of extinguishing the fire, all personnel must evacuate to an assembly location and perform a head count to ensure that personnel are accounted for and are safely evacuated. The FTM or knowledgeable employee will provide the fire department with relevant information.

10.10.1.2 Spills

In the event of a spill or leak, the employee making the discovery will immediately vacate the area and notify other personnel and his/her supervisor. The supervisor will determine whether the leak is an incidental spill or whether an emergency response is required. If there is a probability that the spill will extend beyond the immediate area, result in an environmental insult, or exceed the capabilities of the on-site personnel, the supervisor is to inform the PSS, who will determine whether a response by the PGDP spill response team is warranted. If emergency response crews are mobilized, the supervisor or knowledgeable employee will provide the responders with relevant information.

10.10.1.3 Medical Emergencies

The DOE Prime Contractor first aid/CPR provider will serve as the designated first aid provider. Any event that results in potential employee exposure to bloodborne pathogens will require a post-event evaluation and follow-up consistent with 29 CFR 1910.1030. The supervisor will be notified as soon as practical after notifying the PSS. A person knowledgeable of the location and nature of the injury will meet the emergency response personnel to guide them to the injured person.

Site personnel may take workers with injuries that are more severe than can be addressed by first aid, but that do not constitute a medical emergency, to Lourdes Hospital. The FTM, ES&H Representative, and RI Project Manager must be informed immediately that the worker has been taken to the medical facility and the nature of the injury. Available medical facilities include the on-site clinic at PGDP and Lourdes Hospital in Paducah. Lourdes Hospital is located at 1530 Lone Oak Road, Paducah, Kentucky.

10.10.2 Reporting An Emergency

Project personnel will be able to communicate by two-way, hand-held radio, or cellular telephone on-site.

10.10.2.1 Telephone

Inside the PGDP security perimeter, if a plant telephone is accessible, dial 6333. With a cellular phone, dial 441-6333. Describe the type and the location of the emergency. Identify who is calling. Identify the number on the phone being used. Tell whether an ambulance is needed. Listen and follow any instructions that are given. Do not hang up until after the Emergency Control Center has hung up.

10.10.2.2 Fire Alarm Pull Boxes

Pulling a fire alarm box at PGDP automatically transmits the location of the emergency to the Fire Department and the Emergency Control Center. The person pulling the alarm should remain at the alarm box, or nearest safe location, and supply any needed information to the emergency responders. Work personnel should note the location of pull boxes in each project area. (There are no fire alarm pull boxes at any of the field sites.)

10.10.2.3 Radio

Within three to five miles of PGDP, site radio communications should be effective. By calling radio call number Alpha 1 and declaring "EMERGENCY TRAFFIC, EMERGENCY TRAFFIC," the PSS is alerted of the emergency. Describe the type and the location of the emergency. Identify who is calling.

10.10.3 Alarm Signals

10.10.3.1 Project-Specific Alarm

A prolonged blast of an air horn or vehicle horn will signal immediate work stoppage and evacuation to a pre-designated area. The alarm signal will be tested at project initiation to verify adequate volume.

10.10.3.2 Evacuation Alarms

PGDP facility evacuation alarms are denoted by a steady or continuous sound from the site public address system. Proceed to the predetermined assembly station. The assembly station director will provide further instruction.

10.10.3.3 Radiation Alarms

PGDP radiation alarms are denoted by a steady sound from a clarion horn and rotating red beacon lights. Evacuate the site or area and proceed to the predetermined assembly station. The assembly station director will give further instruction.

10.10.3.4 Take-Cover Alarms

PGDP take-cover alarms are denoted by an intermittent or wailing siren sound from the site public address system. Seek immediate protective cover in a strong sheltered part of a building. Evacuate mobile structures to a permanent building or underground shelter.

10.10.3.5 Standard Alerting Tone

The standard alerting tone at PDGP is a high/low tone from the public address system and is repeated on the plant radio frequencies. Listen carefully; an emergency announcement will follow.

10.10.4 Evacuation Procedures

The ES&H Representative or FTM will designate the evacuation routes. Every on-site worker should familiarize himself/herself with the evacuation routes. In the event of an evacuation, proceed to the predetermined assembly station or designated area and wait for further instructions.

10.10.5 Sheltering In Place

Certain emergency conditions (e.g., chemical or radioactive material release, tornado warning, fire, security threat) may require that personnel be sheltered in place. Notification of a recommendation of "sheltering in place" is carried out by the PGDP Emergency Director on the emergency public address system and plant radio frequencies. Requirements for "sheltering in place" follow these steps:

- Go indoors immediately (permanent building or underground shelter, not "mobile-type" structures);
- Close all windows and doors;
- Turn off all sources of outdoor air (e.g., fans and air conditioners);
- Shut down equipment and processes, as necessary, for safety; and
- Remain indoors and listen for additional information on the public address system.

10.10.6 On-Site Relocation

Certain emergency conditions (e.g., chemical or radioactive material release, tornado warning, fire, security threat) may require that on-site personnel be relocated from their normal workstations and activities to locations more suitable to withstand the threat. Notification of on-site relocation is carried out by the PGDP Emergency Director on the public address system and plant radio frequencies. Specific instructions about where to relocate will be given with the message.

10.10.7 Facility Evacuation

For evacuations related to emergencies inside PGDP, the PGDP Emergency Director initiates notification of facility evacuation over the public address system. Assembly stations serve as gathering points for evacuating personnel. These stations are identified with an orange, disk-shaped sign with the assembly station number in black lettering. In the event of an evacuation alarm, employees will evacuate to the designated assembly point for the area and immediately report to the FTM or the assembly station director. An accounting will be conducted of all personnel who have evacuated. Further instructions and information about the emergency situation will be given to employees by the assembly station director or over the site public address system and plant radio.

10.10.8 Emergency Equipment

The following items of emergency equipment will be maintained at the work location:

- Hard-wired or cellular telephone and radios;
- First aid kit including bloodborne pathogen PPE;
- ABC-rated fire extinguishers;
- Basic spill kit suitable to handle small spills; and
- Airhorn or other audible signal.

10.11 HEAT AND COLD STRESS

The most common types of stress that affect field personnel are from heat and cold. Heat stress and cold stress may be the most serious hazards to workers at waste sites. In light of this, it is important that all employees understand the signs and symptoms of potential injuries associated with working in extreme temperatures.

10.11.1 Heat Stress

Heat stress occurs when the body's physiological processes fail to maintain a normal body temperature because of excessive heat. The body reacts to heat stress in a number of different ways. The reactions range from mild (such as fatigue, irritability, anxiety, and decreased concentration) to severe (such as death). Heat-related disorders are generally classified in four basic categories: heat rash, heat cramps, heat exhaustion, and heat stroke. The descriptions, symptoms, and treatments for these diseases are described in the following sections.

10.11.1.1 Heat Rash

Description. Heat rash is caused by continuous exposure to heat and humid air and is generally aggravated by coarse clothing. This condition decreases the body's ability to tolerate heat, but is the mildest of heat-related disorders.

Symptoms. Mild red rash is generally more prominent in areas of the body in contact with PPE.

Treatment. Decrease the amount of time in PPE and use powder to help absorb moisture.

10.11.1.2 Heat Cramps

Description. Heat cramps are caused by perspiration that is not offset by adequate fluid intake. This condition is the first sign of a situation that can lead to heat stroke.

Symptoms. Acute, painful spasms of the voluntary muscles (e.g., abdomen and extremities).

Treatment. Remove victim to a cool area and loosen clothing. Have victim drink one to two cups of water immediately and every 20 minutes thereafter until the symptoms subside. Consult a physician.

10.11.1.3 Heat Exhaustion

Description. Heat exhaustion is a state of very definite weakness or exhaustion caused by the loss of fluids from the body. This condition is more severe than heat cramps.

Symptoms. Pale, clammy, moist skin with profuse perspiration and extreme weakness. Body temperature is generally normal, but the pulse is weak and rapid. Breathing is shallow. The victim may show signs of dizziness and may vomit.

Treatment. Remove the victim to a cool, air-conditioned atmosphere. Loosen clothing and require the victim to lie in a flat position with the feet slightly elevated. Have the victim drink one to two cups of water immediately and every 20 minutes until the symptoms subside. Seek medical attention, particularly in severe situations.

10.11.1.4 Heat Stroke

Description. Heat stroke is an acute, dangerous situation. It can happen in a very short time. The victim's temperature control system shuts down completely, resulting in a rise in body core temperature to levels that can cause brain damage and can be fatal if not treated promptly and effectively.

Symptoms. Red, hot, dry skin, with no perspiring. Rapid respiration, high pulse rate, and extremely high body temperature.

Treatment. Cool the victim quickly. If the body temperature is not brought down quickly, permanent brain damage or death can result. The victim should be soaked in cool water. Get medical attention as soon as possible.

10.11.1.5 Preventive Measures

A number of steps can be taken to minimize the potential for heat stress disorders.

- Acclimate employees to working conditions by slowly increasing work loads over extended periods of time. Do not begin site work activities with the most demanding physical expenditures.
- As practicable, conduct strenuous activities during cooler portions of the day, such as early morning or early evening.
- Provide employees with lots of tempered water and encourage them to drink it throughout the work shift; discourage the use of alcohol during nonworking hours. It is essential that fluids lost through perspiration be replenished. Total water consumption should equal one to two gal/day.
- During hot periods, rotate employees wearing impervious clothing.
- Provide cooling devices as appropriate. Mobile showers and/or hose-down facilities, powered air purifying respirators, and ice vests have all proven effective in helping prevent heat stress.

10.11.1.6 Heat Stress Monitoring

For strenuous field activities that are part of ongoing site activities in hot weather, the following procedures are used to monitor the body's physiological response to heat. These procedures will be implemented when employees are required to wear impervious clothing in atmospheres exceeding 70 F.

- Monitor Heart Rate. Heart rate should be measured by the radial pulse for 30 seconds as early as possible in the resting period. This measurement should not exceed 110 beats per minute; if it does, the next work period should be shortened by 33%, with the length of the rest period remaining the same. If the heart rate still exceeds 110 beats per minute at the beginning of the next rest period, the following work cycle should likewise be shortened by 33%. This procedure continues until the rate is maintained below 110 beats per minute.
- Monitor Body Temperature. Body temperature is measured orally with a clinical thermometer as early as possible in the resting period. Body temperature should not exceed 99.6°F; if it does, the next work period should be shortened by 33%. If the temperature at the end of the next work period still exceeds 99.6°F, the following work cycle is shortened by another 33%. This procedure continues until the body temperature is maintained below 99.6°F.

The work/rest schedules below are provided as a guideline for workers in Level C or Level B PPE.

Adjusted temperature (°F)[a]	Work schedule (min/hour)
75	50
80	40
85	30
90	20
95	10
100	0

[a] Adjusted temperature is the sum of the actual temperature plus the product of 13 times the fraction of sunshine. The fraction of sunshine is an estimate of the percentage of the time that the sun is not overcast by clouds.

The guidelines set forth in the current issue of the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values and Biological Indices shall be used to determine the work/rest regimen for working in environments conducive to heat stress.

10.11.2 Cold Stress

Persons working outdoors in low temperatures, especially at or below freezing, are subject to cold stress disorders. Exposure to extreme cold for even a short period of time can cause severe injury to the body surfaces and/or profound cooling, which can lead to death. Areas of the body that have high surface-area-to-volume ratios, such as fingers, toes, and ears, are the most susceptible.

Two basic types of cold disorders exist: localized (e.g., frostbite) and generalized (e.g., hypothermia). The descriptions, symptoms, and treatments for frostbite and hypothermia are provided below.

10.11.2.1 Frostbite

Description. Frostbite is a condition in which the fluids around the cells of body tissues freeze, damaging the tissues. The most vulnerable parts of the body are the nose, cheeks, ears, fingers, and toes.

Symptoms. Affected areas become white and firm.

Treatment. Get the individual to a warm environment and rewarm the areas quickly. Keep affected areas covered and warm. Warm water can be used to thaw the areas.

10.11.2.2 Hypothermia

Description. As the temperature of the body drops, the thermoregulatory system attempts to increase the body’s generation of heat, blood vessels are constricted to conserve energy, and glucose is produced to increase the body’s metabolic rate (i.e., glucose is used as fuel to generate heat).

Symptoms. Uncontrollable shivering with the sensation of cold. Slower heartbeat and weaker pulse.

Treatment. Get individual to a warm environment.

10.11.2.3 Preventive Measures

A number of steps can be taken to minimize the potential for cold stress.

- Individuals can achieve a certain degree of acclimation when working in cold environments as they can for warm environments. The body will undergo some changes that increase the body's comfort and reduce the risk of cold injury.

- Working in cold environments causes significant water losses through the skin and the lungs as a result of the dryness of the air. Increased fluid intake is essential to prevent dehydration, which affects the flow of blood to the extremities and increases the risk of cold injury. Warm, sweet, caffeine-free, nonalcoholic drinks, as well as, soups should be readily available.

- The skin should not be continuously exposed to subzero temperatures.

10.11.2.4 Cold Stress Monitoring

Air temperature alone is not a sufficient criterion on which to judge the potential for cold-related disorders in a particular environment. Heat loss from convection (air movement at the surface of the skin) is probably the greatest and most deceptive factor in the loss of body heat. For this reason, wind speeds as well as air temperatures need to be considered in the evaluation of the potential for cold stress disorders. The ACGIH Threshold Limit Values and Biological Indices provide additional guidance on cold stress evaluation and the establishment of the work/rest regimen in environments conducive to cold stress.

10.12 HOUSEKEEPING

Work zones shall be cleaned and wastes and debris will be removed on a daily basis. Tools, materials, welding leads, hoses, or debris shall not be strewn about in a manner that may cause tripping or other hazards. Stored material shall be placed and otherwise secured against sliding or collapse. All slip, trip, and fall hazards will be eliminated.

10.13 HOISTING AND RIGGING PRACTICES

All hoisting and rigging will meet the DOE Prime Contractor hoisting and rigging requirements, as well as those in OSHA 1926, Subpart N, and OSHA 1926.602. Hoisting and rigging equipment will not be modified such that manufacturer's specifications are invalidated.

In order to ensure that personnel are not injured or equipment is not damaged during hoisting and rigging operations, the following safe working guidelines will be utilized. These guidelines include those outlined in OSHA and DOE hoisting and rigging manuals. The ES&H Representative or designee will be on-site during all lifting activities.

10.13.1 General

Hoisting and rigging activities will be reviewed to determine their classification according to the following definitions:

- Nonroutine lift—Parts, components, assemblies, or lifting operations for which dropping, upsetting, or collision of items could result in any of the following:

  — cause significant work delay,

  — cause undetectable damage resulting in future operational or safety problems,

— result in significant release of radioactivity or other serious and undesirable environmental conditions, and/or

— present a potentially unacceptable risk of personal injury or property damage.

- Routine lift—Any lift not designated as a nonroutine lift.

  All lifts on this project are expected to be routine. If an added scope of work requires a nonroutine lift, a separate Hoisting and Rigging Plan will be developed and submitted before the lift proceeds.

10.13.2 Hoisting

Only designated and qualified personnel will operate hoisting equipment. Hoisting operators will be in visual or radio contact with a flag person before, and during, every lift. If visual or radio contact is interrupted for any reason, the operator will stop the lift until full contact is restored.

- The equipment will be capable, within the manufacturer's specifications, of fulfilling all requirements of the work without endangering personnel or equipment.

- Equipment with outriggers will have the outriggers fully extended and set before all lifts.

- Before lifting, operators will know the total weight of the load.

- The operator will check the load line brake and crane for stability when the load is only inches from the ground, before proceeding with any lift. This lift of a few inches will be considered a "trial lift."

- A suspended load never will be left unattended. An operator will not leave the control station of a crane during a lift except under the conditions listed here.

- The hoist line will be vertical at all times.

- Personnel will not stand or pass under suspended loads.

- A tag line(s) will be required on all loads. As many tag lines as necessary will be used to adequately control the load while landing.

- A crane load chart for the crane, as configured, will be posted in the cab of each crane, along with the rated load capacities, recommended operation speeds, and special hazard warnings or instructions.

- Cranes will be inspected in accordance with the guidelines provided below:

  — Applicable American National Standards Institute, Inc. (ANSI) B30-series daily, monthly, quarterly, semiannual, annual, and special inspections will be completed before any crane is operated.

  — A qualified inspector following the manufacturer's recommendations and specifications will complete all inspections.

  — The annual certification sticker will be prominently displayed on the crane, but in such a manner that it does not obstruct the operator's view of any work operation.

— Borrowed, rented, or leased cranes will be inspected before on-site use by the qualified crane inspector regardless of any other signed inspection forms.

10.13.3 Rigging

- Rigging equipment for material handling will be visually inspected before use and as necessary during its use to ensure that it is safe. Defective rigging equipment will be removed from service and repaired or destroyed. All rigging equipment will be load-tested at least annually by a competent person who, by training or experience, can recognize defects and take appropriate action to correct them.

- Rigging equipment will not be loaded in excess of its recommended safe working load, as prescribed in Tables H-1 through H-20 of OSHA 29 CFR 1926 Subpart H (29 CFR 1926.251, "Rigging Equipment for Material Handling"). Rigging equipment for material handling during drilling activities shall be inspected prior to use on each shift and, as necessary, during its use to ensure that it is safe. Defective rigging equipment shall be removed from service per CFR 1926.251.

- Special hoisting devices, slings, chokers, hooks, clamps, or other lifting accessories will be marked to indicate the safe working loads and will be proof-tested to 125% of their rated load before initial use.

10.14 HEARING CONSERVATION

- Exposures to noise levels greater than 85 decibels (dBAs) will require hearing protection.

- Noise reduction ratings of hearing protection must be sufficient to reduce exposure to less than 85 dBAs.

- No unprotected exposure to noise levels greater than 115 dBAs will be allowed.

- Employees exposed to noise in excess of a time-weighted average of 85 dBAs must have annual audiograms.

- Engineering controls shall be used when possible to restrict noise to less than 85 dBAs.

- Areas with noise levels above 85 dBAs will be posted.

10.15 PERSONNEL DECONTAMINATION

Decontamination procedures will vary with different stages of work and with work conditions. The ES&H Representative and Radiological Control Technician (RCT) will determine decontamination requirements to minimize potential for spread of contamination from work zones.

10.16 RADIOLOGICAL PROTECTION

The radiological contaminant of concern is ^{99}Tc. Due to varying levels of ^{99}Tc some work may be performed under a Radiological Work Permit (RWP).

10.16.1 Radiation Protection Plan

All workers will operate under the DOE-approved Radiological Protection Program (RPP) when performing activities where a potential hazard is posed by radiation exposure. The DOE Prime Contractor will assess all radiological hazards that may be encountered. This has been accomplished primarily through the preparation of this ES&H plan. Based on these evaluation activities, appropriate engineering, administrative, and PPE controls will be selected and implemented. Whenever possible, work will be arranged to avoid (or at least minimize) entry into radiological areas. The radiation safety work practices focus on establishing controls and procedures for conducting work with radioactive material, while maintaining radiation exposures as low as reasonably achievable (ALARA).

All work associated with radiological issues will be conducted in accordance with the RPP, and, as a result, the DOE Prime Contractor will provide radiological support services activities with potential radiation exposure. RCTs also may perform surveys and monitoring, coordinate dose assessments, identify radiological areas, and prepare Radiation Work Authorizations or RWPs. All subcontractors will implement and maintain any controls identified as a result of these services.

10.16.2 Contractor/Subcontractor Responsibilities

The DOE Prime Contractor and any subcontractors responsibilities may include the following:

- Provide and erect any radiological barriers, barricades, warning devices, or locks needed to safely control the work site.
- Follow the requirements of the RWPs, including daily briefings, and requirements for signing in on all RWPs.
- Submit bioassay samples and use external dosimeters.
- Notify ten days in advance of work shift changes, work schedule changes, or special radiological survey needs that require an increase in the number of RCTs assigned to the project.
- Notify the RI Project Manager within three working days after any employee declares a pregnancy.
- Establish radiation control measures that comply with the requirements specified by radiological personnel supporting the project.
- Determine required radiological PPE based on appropriate work processes and AHAs.

10.16.3 Site-Specific Radiation Safety Work Practices

The DOE Prime Contractor and all subcontractors will implement the following radiation safety work practices when working in radiological areas:

- All personnel will adhere to the action levels and hold points identified in the RWP addressing the potential radiological hazards posed by work activities. Work practices and PPE will be altered according to changing radiological requirements as prescribed by the RWP and/or the RCT.
- All work activities to be performed will be designed and performed ensuring minimization of material brought into the Radiological Areas. Management, design engineers and field personnel will jointly identify the materials and equipment needed to perform this work. Only equipment and

supplies necessary to successfully accomplish the various tasks to be performed will be taken into the EZ. Work also will be planned and conducted in a manner that minimizes the generation of waste materials. All activities will be designed, before commencement of field activity to maintain radiation exposures and releases ALARA. Emphasis will be placed on engineering and administrative controls over the use of PPE, when feasible.

- All personnel working in, or subject to, work in the Radiological Areas will read the applicable RWP. The ES&H Representative also will verbally review the RWP during the initial pre-work safety briefing. The FTM and the ES&H Representative will continuously monitor worker compliance with the RWP. The FTM and/or the ES&H Representative will communicate changes to the RWP immediately to all affected personnel, and work practices will be changed accordingly. Radiological controls specified by the RWP, such as PPE and work activity hold points, will be reviewed during "tailgate" safety briefings.

- All lower-tier subcontractors will be required to read and comply with this Radiation Safety Plan and applicable RWP. Applicable portions of this plan will be verbally briefed to field personnel and lower-tier subcontractors during the pre-work safety briefing.

- Engineering and administrative controls will be utilized to minimize and control the spread of airborne and surface contamination. If airborne contamination is identified, water mist will be used to eliminate or reduce this hazard. The contaminated water will be contained by plastic sheeting covering the work area. Surface contamination, in the form of waste, will be containerized in metal drums throughout the drilling process.

- Personnel will be instructed in the proper use and care of external dosimeters before commencement of field activities and periodically during pre-work tailgate briefings. Personnel will be instructed to wear the dosimeters only during activities posing an occupational ionizing radiation exposure. This will include all field activities. Personnel will be instructed to wear their dosimeters outside of company clothing in the front torso area of the body. They are not to expose the dosimeters to excessive heat or moisture. Dosimeters must be exchanged on a quarterly basis.

- All personnel will participate in the DOE Prime Contractor Bioassay Program. All personnel will have submitted a baseline bioassay sample before receiving an external dosimeter and participating in any fieldwork. Periodic bioassays also will be submitted in a timely manner as directed by RADCON. Personnel not complying with these requirements will be subject to removal from the project.

- The FTM and the ES&H Representative will conduct a continuous observance of work in progress and of field personnel performance with respect to ALARA. Additional reviews of performance will be discussed during "tailgate" safety meetings with all field personnel. All lessons learned will be noted in the ES&H Representative's field logbook. Work practices will be modified to incorporate lessons learned. A post-job ALARA review will be conducted by the ES&H Representative with input from the FTM, field personnel, and previous lessons learned recorded in the ES&H Representative logbook.

10.16.4 Radiation Safety Training

The DOE Prime Contractor and all subcontractors will observe the radiological training requirements, which require GET and Radworker II Training for all general employees who will perform hands-on work in radiological areas. The applicability of this training will be determined for each activity.

Personnel, including visitors who are not necessary to the performance of the scope of work and who are not appropriately trained and qualified, will not enter any work areas where radiological exposures may occur. In areas where visitors are essential or otherwise approved to be present, they will be restricted from Contamination Areas, High Contamination Areas, High Radiation Areas, Very High Radiation Areas, or Airborne Radiation Areas. In all other radiological areas, visitors may be present only if escorted by a qualified radiological worker and will perform no hands-on activities.

11. QUALITY ASSURANCE PLAN

The following QA elements are contained in *EPA Requirements for QA Project Plans* (QA/R-5) and *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans* (QAMS-005). This locator is a crosswalk between those elements and the related sections of this QA plan for the BGOU RI/FS field activities.

QA/R-5 AND QAMS-005 LOCATOR PAGE

QA/R-5	**QAMS-005/80**	**Section number and title in Quality Assurance Plan**
A1 Title Page and Approval Sheet	1.0 Title Page with Provision for Approval Signatures	Approval Page
A2 Table of Contents	2.0 Table of Contents	Contents
A3 Distribution List		Distribution List
A4 Project/Task Organization	4.0 Project Organization and Responsibility	11.2 Project QA Responsibility
A5 Project Definition/Background	3.0 Project Description	11.1 Project Description
A6 Project/Task Description	3.0 Project Description	11.1 Project Description
A7 Quality Objectives and Criteria	5.0 QA Objectives for Measurement (PARCC)	11.5 QA Objectives for Measurement of Data
A8 Special Training/Certification	4.0 Project Organization and Responsibility	11.3 Personnel Qualifications and Training
A9 Documents and Records	4.0 Project Organization and Responsibility	11.4 Document Control and Records Management
B1 Sampling Process Design B2 Sampling Methods	6.0 Sampling Procedures	11.6 Sampling Procedures
B3 Sample Handling and Custody	7.0 Sample Custody	11.7 Sample Custody
B4 Analytical Methods	9.0 Analytical Procedures	11.9 Analytical Procedures
B5 Quality Control	11.0 Internal Quality Control Checks and Frequency	11.11 Internal Quality Control Checks
B6 Instrument/Equipment Testing, Inspection, and Maintenance	13.0 Preventative Maintenance	11.13 Preventive Maintenance
B7 Instrument/Equipment Calibration And Frequency	8.0 Calibration Procedures and Frequency	11.8 Instrument Calibration and Frequency
B8 Inspection/Acceptance of Supplies and Consumables		11.17 Inspection of Materials
B9 Non-direct Measurements	10.0 Data Reduction, Validation, and Reporting	11.10 Data Review and Reporting
B10 Data Management	10.0 Data Reduction, Validation, and Reporting	11.10 Data Review and Reporting
C1 Assessment and Response Actions	12.0 Performance and Systems 15.0 Corrective Action	11.12 Audits and Surveillances
C2 Reports to Management	16.0 QA Reports to Management	11.15 QA Reports to Management 11.16 Field Changes
D1 Data Review, Verification, and Validation	10.0 Data Reduction, Validation, and Reporting	11.10 Data Review and Reporting
D2 Verification and Validation Methods	10.0 Data Reduction, Validation, and Reporting	11.10 Data Review and Reporting
D3 Reconciliation with User Requirements	14.0 Specific Routine Procedures Measurement Parameters Involved	11.14 Reconciliation with User Requirements

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10 CFR 830.122 LOCATOR PAGE

The following ten QA elements are discussed in 10 CFR§ 830.122. This locator is a crosswalk between those ten elements and the related sections of the governing QA documents for the BGOU RI/FS field activities.

10 CFR 830.122 Element	BGOU RI/FS Work Plan Project Reference
1. Management	
(i) Program	DOE Prime Contractor and Subcontractor QA Programs
(ii) Personnel Training and Qualification	Sections 10.6, 11.3, and 13.4.5
(iii) Quality Improvement	Section 11.12, 11.15, and 11.16
(iv) Documents and Records	Sections 11.4 and 12.3
2. Performance	
(i) Work Processes	Chapter 9, the FSP
(ii) Design	Chapter 9, the FSP
(iii) Procurement	DOE Prime Contractor and Subcontractor QA Programs
(iv) Inspection and Acceptance Testing	Section 11.17
3. Assessment	
(i) Management Assessment	Section 11.12

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11.1 PROJECT DESCRIPTION

This QAPP has been developed specifically for the BGOU RI/FS investigation. Previous sections of this document (hereafter referred to as the work plan), present the basic strategies and procedures that will apply to sampling conducted as part of the BGOU RI/FS field activities (Chapter 9).

11.2 PROJECT ORGANIZATION

Roles and responsibilities of the project team are detailed in Table 11.1.

Adherence to the QA/QC requirements in this QAPP will require coordination and integration between QA representatives from the DOE Prime Contractor and the Subcontractor Team. The roles and responsibilities for the QA representatives are discussed in Table 11.1. The QA Specialist will assume responsibility for day-to-day QA activities associated with the investigation project and all QA issues related to the QA program. The DOE Prime Contractor QA Manager will provide QA oversight and coordination with DOE and the regulatory agencies on all QA issues.

11.3 PERSONNEL QUALIFICATIONS AND TRAINING

Personnel assigned to the project, including field personnel and subcontractors, will be qualified to perform the tasks to which they are assigned. Resumes of project personnel will be provided to the DOE Prime Contractor RI Project Manager to document their training and experience. In addition to education and experience, specific training may be required to qualify individuals to perform certain activities. Training will be documented on appropriate forms, which will be placed in the project file. Project personnel will receive an orientation to the following documents, as well as to their responsibilities, before participating in project activities.

- FSP (Chapter 9)
- Site-Specific ES&HP (Chapter 10)
- QAPP (Chapter 11)
- DMIP (Chapter 12)
- WMP (Chapter 13)

A field-planning meeting will be the forum for the orientation. All field personnel will be required to read and familiarize themselves with these documents before performing any work at the site. A copy of these documents will be available to all field personnel while in the field. The QA Specialist will be responsible for ensuring the most current copy of these documents is available. All sampling procedures will be performed in compliance with the FSP. At a minimum, records of required reading reports and attendance lists will be maintained.

Training will be conducted in accordance with Contractor-approved procedures. A training profile (required training for each work assignment) will be established for each individual. Changes in controlled documents will be monitored and training assignments will be issued to individuals as changes occur. The QA Specialist will be the point of contact for training.

Table 11.1 Roles and Responsibilities

Role	Responsibility
DOE Project Manager	Responsible for project oversight. This individual also will be the primary interface between the EPA and KDEP regulators and the DOE Prime Contractor and Subcontractors.
DOE Prime Contractor ER Manager	Responsible programmatically for technical, financial, and scheduling matters; will interface with the DOE and regulators, as appropriate.
DOE Prime Contractor RI Project Manager	Responsible for management and integration of subcontractor implementation of this investigation. Responsible for implementing the investigation, including all plans and field activities conducted as part of the RI including monitoring the performance of sampling and waste management activities; serves as the technical lead and principal point of contact with the DOE Project Manager; tracks project budget and schedules and delegates specific responsibilities to project team members; responsible for preparing any field change orders.
Site ES&H Representative	Ensures that health and safety procedures designed to protect personnel are maintained throughout the field effort for this project; ensures the implementation of an ISMS for all aspects of the RI. ISMS is dedicated to the concept that all accidents are preventable. Accordingly, the DOE Prime Contractor, the Project Team, and all sub contractors will be expected to achieve and sustain "Zero-Accident Performance" through continuous improvement practices. "Zero-Accident Performance" includes zero unpermitted discharges or releases with respect to protection of the environment.
QA Manager	Provides QA oversight and approval for the project; conducts audits and surveillances and approves any field changes that may impact the project quality.
QA Specialist	Provides QA oversight for all day-to-day QA activities associated with the investigation project and all QA issues related to the QA program; provides technical oversight for all field team activities during the investigation.
FTM	Responsible for all activities relating to identification, acquisition, classification, indexing, and storage of project records related to the investigation; will include data documentation materials, plans, procedures, and all project file requirements.
Subcontractors	Responsible for providing the labor and expertise in conducting the investigation.
WMC	Ensures adherence to the WMP as described in Chapter 13; documents and tracks field-related activities, including waste generation and handling, waste characterization sampling, waste transfer, and waste labeling. The WMC will perform the majority of waste handling field activities.
Sample Management/Data Coordinator	Responsible for the coordination of all investigation-sampling activities, including coordination with the DOE Prime Contractor SMO. This individual will ensure that all quality control sampling requirements are met, chain-of-custody forms are generated properly, and that compliance with off-site shipping requirements is achieved. The Sample Management/Data Coordinator will be responsible for managing data generated during the investigation in accordance with the DMIP, Chapter 12.

11.4 DOCUMENT CONTROL AND RECORDS MANAGEMENT

Document control and records management plans will be implemented according to Contractor-approved procedures.

11.5 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

11.5.1 Data Quality Objectives

DQOs are qualitative statements developed by data users to specify the quality of data from field and laboratory data collection activities to support specific decisions or regulatory actions. The DQOs describe what data are needed, why the data are needed, and how the data will be used to address the problems being investigated. DQOs also establish numeric limits to ensure that data collected are of sufficient quality and quantity for user applications. The principal study questions and decision statements for this investigation are discussed in Table 1.1.

11.5.2 Data Categories

Two descriptive data categories have been specified by EPA in *Data Quality Objectives Process for Superfund*, Interim Final Guidance, EPA/540/G-93/071 (EPA 1993). These two data categories supersede the five QC levels (Levels I, II, III, IV, and V) defined in EPA's *Data Quality Objectives for Remedial Response Activities, Development Process*, 1987. The two new data categories are associated with specific QA/QC elements and may be generated using a wide range of analytical methods. The two data categories are described below.

- **Screening data with definitive confirmation.** Screening data provide analyte identification and quantification using rapid analytical methods. The primary difference between screening data and definitive data is the level of QA/QC required. The QA/QC requirements for screening data are as follows:

  — Sample documentation (location, date and time collected, batch, etc.);

  — Sample chain-of-custody (when appropriate);

  — Sampling design approach;

  — Initial and continuing calibration;

  — Determination and documentation of detection limits;

  — Identification of compounds and analytes detected;

  — Quantification of compounds and analytes detected;

  — Analytical error determination; and

  — Definitive confirmation.

  At least 10% of the screening data must be confirmed with definitive data.

- **Definitive data.** Definitive data are generated using EPA-approved or other nationally recognized analytical methods. Data are compound- or analyte-specific; the identity and concentration of the analyte are confirmed. Data can be generated on-site or at an off-site, fixed-base laboratory as long as the following QA/QC elements are satisfied:

  — Sample documentation (location, date and time collected, batch, etc.);

— Sample chain-of-custody (when appropriate);

— Sampling design approach;

— Initial and continuing calibration;

— Determination and documentation of detection limits;

— Identification of compounds and analytes detected;

— Quantification of compounds and analytes detected;

— QC blanks (trip, method, equipment rinsates);

— Matrix spike (MS) recoveries;

— Analytical error determination (measures precision of analytical method); and

— Total measurement error determination (measures overall precision of measurement system from sample acquisition through analysis).

Definitive data will be collected and analyzed in a fixed-base laboratory when the BGOU RI/FS is implemented. Field measurements collected during the BGOU RI/FS will be measured in the field using appropriate field instruments. Table 11.2 summarizes the data uses, data users, data categories, and data deliverable QC levels for each of the media and sample types that will be collected during this investigation.

Table 11.2 Data Uses and QC Levels

Field activity/media	Intended uses	Intended users[a]	Data category
Health and Safety Monitoring	Determination of appropriate protection levels for field personnel.	Field Personnel Project Technical Support	None specified
Field Measurements	Field analysis of groundwater parameters, such as pH, temperature, dissolved oxygen, etc.	Project Manager Field Personnel Project Technical Support	Screening with definitive confirmation
Field Screening	Screening samples for radionuclides before off-site shipment. Field analysis to determine presence and concentration of radiological-indicator chemicals.	Project Manager Field Personnel Project Technical Support	Screening with definitive confirmation
Water Samples	Determine presence and concentration of contamination.	Project Manager Project Technical Support	Definitive
Soil Samples	Determine presence and concentration of contamination.	Project Manager Project Technical Support	Definitive

[a] Secondary data users are listed. Primary data users include DOE, DOE Prime Contractor, EPA, and KDEP personnel.

11.5.3 Intended Uses of Acquired Data

The intended uses of the acquired data are to meet the DQOs and address the data gaps associated with SWMUs 2, 3, 4, 5, 6, 7 and 30, and 145, as identified in Chapter 1.

11.5.4 Intended Users of Data

The primary users of the data acquired during the BGOU RI/FS will be the following groups or organizations.

- DOE, KDEP, EPA, and the public will use data to select the remedial alternative.
- The Project Team will use the data to make the determinations described in Section 11.5.3 of this QAPP.
- The Project Team will present the results of the investigation in a report to DOE. In consultation with DOE, EPA, and the KDEP, the Project Team will make a decision as to whether further action is required.
- The data management team will add these data to OREIS.

11.5.5 PARCC Parameters

Precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters are tools by which data sets can be evaluated. Evaluation of PARCC parameters helps ensure that DQOs are met. Table 11.3 displays QA objectives for laboratory measurements.

- **Precision** refers to the level of agreement among repeated measurements of the same characteristic, usually under a given set of conditions. To determine the precision of the laboratory analysis, a routine program of replicate analyses is performed. Duplicate field samples will be collected to determine total measurement (sampling and analytical) precision. The precision of field instrument measurements will be based on manufacturers' data (see Table 11.4).
- **Accuracy** refers to the nearness of a measurement to an accepted reference or true value. To determine the accuracy, the evaluation is applied over the entire range of concentrations. To determine the acuracy of an analytical method and/or the laboratory analysis, a periodic program of sample spiking is conducted (minimum 1 spike and 1 spike duplicate per 20 samples).

In addition, a Laboratory Control Sample will be performed for each batch and plotted on control charts. Accuracy of the Laboratory Control Sample will be evaluated in accordance with laboratory statistical guidelines.

Accuracy and precision of data collected in the investigation will depend on the measurement standards used and their meticulous, competent use by qualified personnel. Objectives for laboratory accuracy and precision for this project are shown in Table 11.3 for fixed-base laboratory measurements and Table 11.4 for field measurements. The compound-specific precision and accuracy objectives will be included in the laboratory QAPP and will be reviewed for appropriateness. Accuracy of field instruments will not be determined; however, frequent calibration and operational checks will be performed (see Sections 11.8.1 and 11.8.2 of this QAPP) to ensure the accuracy of instrument measurements.

- **Representativeness** is the degree to which discrete samples accurately and precisely reflect a characteristic of a population, variations at a sampling location, or an environmental condition. Representativeness is a qualitative parameter and will be achieved through careful, informed selection of sampling sites, drilling sites, drilling depths, and analytical parameters and through the proper collection and handling of samples to avoid interference and minimize contamination and sample loss.

Table 11.3 QA Objectives for Fixed-base Laboratory Measurements

Parameter	Method	Matrix	Precision[a]	Accuracy	Completeness
TCL volatiles	SW-846[b] 8260	Soil	22%	80–100%	90%
TCL volatiles	SW-846 8260	Water	13%	80–100%	90%
TCL semivolatiles	SW-846 8270	Soil	38%	80–100%	90%
TAL metals	SW-846 6010, 6020, and 7000 series	Soil	35%	80–100%	90%
TCL PCBs	SW-846 8082	Soil	43%	80–100%	90%
TCL PCBs	SW-846 8082	Water	21%	80–100%	90%
Gross alpha	EPA 900/HASL-300[c]	Soil	30%	80–100%	90%
Gross beta	EPA 900/HASL-300	Soil	25%	80–100%	90%
Uranium-234, Uranium-235, and Uranium-238	HASL-300	Soil	20%	80–100%	90%
Uranium-234, Uranium-235, and Uranium-238	HASL-300	Water	20%	80–100%	90%
Technetium-99, Thorium-230, Plutonium-99, Cesium-137, and Neptunium-237	HASL-300	Soil	50%	80–100%	90%
Particle-size distribution	ASTM D422[d]	Soil	NA	NA	90%
Moisture content	ASTM D2216	Soil	NA	NA	90%
pH	SW-846 9045	Soil	10%	NA	90%
Flash point	40 *CFR* 261.21	Soil	NA	NA	90%
Specific gravity	ASTM D954	Soil	NA	NA	90%
Unit weight	No method specified[e]	Soil	NA	NA	90%
Reactivity	SW-846 Section 7.3	Soil	NA	NA	90%
Corrosivity	SW-846 Section 7.2	Soil	NA	NA	90%

Precision and accuracy values shown for radionuclides represent levels of 15 pCi/L and 15 pCi/g and above. Lower levels will have substantially wider precision and accuracy limits.
[a]Precision given as a relative percent difference based on replicates.
[b]EPA 1994. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* Second Edition, Final Update II, SW-846, September.
[c]This procedure is derived from a variety of sources including, but not limited to, *Environmental Measurements Laboratory Procedures Manual,* HASL-300 (DOE 1982) and *Prescribed Procedures for Measurement of Radioactivity in Drinking Water* (900 Series) (EPA 1980). Equivalent laboratory methods may be used for radiological analyses if the laboratory standard operating procedures have been approved by DOE.
[d]*Annual Book of ASTM Standards* (ASTM 1996).
[e]Unit weight can be calculated from moisture content data.
NA = Not applicable
ND = Not determined
TAL = Target Analyte List
TCL = Target Compound List

Table 11.4 QA Objectives for Field Measurements and Field Screening

Parameter	Matrix	Accuracy	Precision	Completenes s
Total organic vapors (air monitoring)	Gas	ND	—	90%
Radiation screening (health and safety monitoring)	Solid	ND	—	90%
Gross alpha/gross beta (shipping	Wipe of sample	ND	Instrument counting	90%
High purity Ge detector	Soil	ND	Instrument counting	90%
Groundwater field paramaeters	Water	ND	ND	90%

[a]Direct reading instrument, incapable of reproducing a value without an air standard because atmospheric concentration varies and is unknown. Users will rely on calibration results to verify proper functioning of instrument.
Ge = Germanium
ND = not determined

- **Completeness** is a measure of the percentage of valid, viable data obtained from a measurement system compared with the amount expected under normal conditions. The goal of completeness is to generate a sufficient amount of valid data to satisfy project needs. For this project, the completeness objective for field and laboratory measurements is 90%.

- **Comparability** is the extent to which comparisons among different measurements of the same quantity or quality will yield valid conclusions. Comparability will be assessed in terms of field standard operating procedures (SOPs), analytical methods, QC, and data reporting. In addition, data validation assesses the processes employed by the laboratory that affect data comparability.

11.6 SAMPLING PROCEDURES

The Project Team will perform sampling work in accordance with DOE Prime Contractor-approved procedures and work instructions. The following subsections provide a brief summary of the key sampling procedure elements for this project.

11.6.1 Sampling Logbook Requirements

Logbooks are used to record field sampling activities and sample records, equipment calibrations, equipment decontamination activities, shipping documentation, health and safety-related notes, and general day-to-day field notes. These logbooks must be bound with a hard cover and have sequentially numbered pages. Each sampling team is issued a field logbook daily that must contain, at a minimum, a table of contents and data log sheets. Field documentation shall conform to guidance, as detailed in the DOE Prime Contractor-approved procedures. Additional information regarding logbooks is provided in the DMIP, Chapter 12.

11.6.2 Field Measurement Requirements

Field measurements may be recorded on appropriate data log sheets or in logbooks. Copies of the data log sheets, if used, will be numbered sequentially, and the number will be tracked in the field logbooks. Data log sheets will specify the appropriate type of information to be placed in each field on the sheet. The Sample Management/Data Coordinator will review data log sheets for completeness and will check the sheets against field logbooks. Field measurement data will be entered manually into Paducah PEMS using appropriate sample tracking and handling guidance procedures.

11.6.3 Sample Collection

During the sample event, three types of analytical samples, (1) field screening samples, (2) characterization samples, and (3) field QC samples, shall be collected and submitted for analysis. Field screening samples, characterization samples, and field quality control samples shall be collected as specified in the BGOU RI/FS Work Plan and DOE Prime Contractor-approved procedures.

All samples shall be collected at the PGDP site. Specific equipment for taking samples shall be determined by the sampling team and approved by the FTM, but must be consistent with EPA Region 4 sampling methodologies and must be documented in the appropriate sampling logbook. The FTM, the Sample Management/Data Coordinator, and the samplers shall determine which sampling methods shall be used; and any deviations shall require the initiation of a Field Change Form, approved by the DOE Prime Contractor, and must be documented in the appropriate sampling logbook.

Sample container, preservation, and holding time requirements shall be in accordance with the EPA Region 4 SOPs, this QAPP, and the project-specific analytical statement of work (SOW). Trip blanks shall be shipped to the field in pre-preserved condition. Field preservation of samples shall be documented in the field logbooks and on the chain-of-custody forms.

11.6.4 Field QC Samples

The number of required QC samples is based on requirements that shall be specified in this QAPP. To ensure reliability of the analytical data to meet the data quality objectives for the project, the following QC samples shall be obtained during sample collection.

- Trip Blanks—Trip blanks are used to detect cross-contamination by VOC during sample shipping and handling. Trip blanks are prepared before sampling and consist of AmericASTM Type II water, or other similar characteristic water, in VOC bottles. Trip blanks shall accompany each rigid container (i.e., cooler) shipped to the laboratory containing samples for volatile organic analysis. Trip blanks are analyzed for VOCs only.

- Field Blanks—A field blank serves as a check on environmental contamination at the sample site. Distilled, deionized water is to be transported to the site, opened in the field, transferred into each type of sample bottle, and returned to the laboratory for analysis of all parameters associated with that sampling event. It also is acceptable for field blanks to be filled in the field support area of stample staging area, transported to the field, and then opened. A field blank may be used as a reagent blank, as needed. Field blanks will be collected at a frequency of one in 20 samples (5%) for each sample matrix.

- Field Duplicate Samples—Field duplicate samples help determine sampling variance. Samples submitted for VOC analyses shall not be homogenized. Field duplicates will be collected, as specified, in appropriate field QC sample procedures. One duplicate for every twenty samples (5%) per matrix shall be analyzed for the same set of analytical parameters as the sample it is duplicating.

- Equipment Blanks or Rinsate Samples—An equipment blank or rinsate sample is a sample of deionized water passed through, or over, decontaminated sampling equipment. Equipment blanks are used as a measure of decontamination process effectiveness and are analyzed for the same parameters as the samples collected with the equipment. Equipment blanks also may be used as reagent blanks, as needed. Equipment blanks are required only when nondisposable equipment is being used. Equipment blanks will be collected at a frequency of one for every 20 samples (5%).

11.6.5 Laboratory QC Samples

A laboratory has been approved by the DOE Prime Contractor SMO to perform all fixed-base laboratory analyses on this project. The SMO will specify and audit the conformance of the laboratory to ensure good laboratory practices and regulatory standards.

11.6.6 Sample Identification, Numbering, and Labeling

Sample identification, numbering, and labeling shall be consistent with the requirements identified in the DMIP, Chapter 12, and shall be applied to sample labels and will follow DOE Prime Contractor-approved procedures.

11.7 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Handling, shipping, and storing samples will adhere to custody requirements of appropriate procedures for sample chain-of-custody forms for sample tracking and handling and for temperature control for sample storage. Handling, shipping, and storage procedures will ensure that sample integrity is maintained for analytical purposes. The general procedures required to properly package, ship, handle, and store containers of samples will consist of DOE Prime Contractor-approved procedures.

During transport of samples from the field to the laboratory, the chain-of-custody requirements, specified in the appropriate DOE Prime Contractor-approved procedures, shall be met. All laboratory samples collected during this project will be transported to the approved laboratory. For shipment of samples to an off-site laboratory, DOT shipping and handling regulations will be met and performed according to DOE Prime Contractor-approved procedures. Gross alpha and gross beta screenings of all samples will be performed if sufficient process knowledge does not exist to allow for sample shipment.

11.8 INSTRUMENT CALIBRATION AND FREQUENCY

11.8.1 Field Equipment Calibration Procedures and Frequencies

The calibration of field instruments will be checked in the field in accordance with a DOE Prime Contractor-approved procedure. Field calibration records will be documented in logbooks and on field data sheets. Calibration frequency is summarized in Table 11.5; an example field calibration record is given in Figure 11.1.

11.8.2 Laboratory Equipment Calibration Procedures and Frequencies

The laboratories will use written, standard procedures for equipment calibration and frequency. These procedures are based on EPA guidance or manufacturers' recommendations and are listed in the EPA-approved analytical methods. Supplemental calibration details, such as documentation and reporting requirements, are given in the laboratory QA plan. The laboratory QA plan will be reviewed and statused by the the DOE Prime Contractor, as part of the laboratory review process. The appropriate references for all analytical parameters are included in the reference section of this document. Standards used for calibration will be traceable to the National Institute of Standards and Technology (NIST) or another nationally recognized standardization entity. Corrective action procedures for improperly functioning equipment will be addressed in the laboratory QA plan. Any calibration failures will be documented with a specific qualifier for the affected results. Calibration records, in accordance with the laboratory QA plan, will be maintained for each piece of measuring and test equipment and each piece of reference equipment. The records will indicate that established calibration procedures have been followed. Records of equipment use will be kept in the laboratory files.

Table 11.5 Field Equipment and Calibration/Functional Check Frequencies

Equipment check frequency	Field usage	Frequency	Calibration/check	Calibration/functional material	Calibration check procedure
Hand-held PID	Health and safety	Daily before use	At end of day	Traceable calibration gas	Manufacturer specifications
Radiation detectors	Field screen, health and safety	Daily before use[a]	At end of day	Alpha, gamma, and beta radioactive sources	Manufacturer specifications
Combustible gas indicator	Health and safety	Daily before use[a]	At end of day	Traceable methane	Manufacturer specifications
Immuno assay detector[b]	Field analysis	Daily before use	Manufacturer Specifications	Manufacturer specifications	Manufacturer specifications
High purity Ge detector	Field analysis	Daily before use	Before and after analytical runs	Manufacturer specifications	Manufacturer specifications
Water quality meter for groundwater parameters	Field analysis	Daily before use	Before and after analytical runs	Manufacturer specifications	Manufacturer specifications

[a]These instruments are calibrated by the manufacturer. A functional check will be conducted daily before use to ensure that the equipment is working.

[b]Any field instrument producing quantitative results at the detection levels listed in Table 11.8 may be used.

PID = photoionization detector

CATEGORY 1 M&TE CALIBRATION LOG								
IDENTIFIER	ITEM DESCRIPTION	CALIBRATION MEASUREMENT			BACKGROUND CHECK	RESPONSE CHECK	NAME	DATE
		PRE	ADJUSTMENT	POST				

Figure 11.1. Example of an Equipment Calibration Log

11.9 ANALYTICAL PROCEDURES

11.9.1 Fixed-Base Laboratory Analytical Procedures

When available and appropriate for the sample matrix, SW-846 methods will be used. When not available, other nationally recognized methods such as those of EPA, DOE, and the ASTM will be used. Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) guidance will be used where appropriate. Table 11.6 presents field screening parameters for BGOU RI/FS sampling. Note that SW-846 methods will be used to analyze target compound list/target analyte list (TCL/TAL) compounds, which are listed in Table 11.7. Table 11.8 summarizes examples of analytical methods for these compounds and sample requirements for laboratory analytical parameters.

Method detection limits (MDLs) are the extent to which the equipment or analytical processes can provide accurate, minimum data measurements of a reliable quality for specific constituents. MDL is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The actual quantitation limit for a given analysis will vary depending on instrument sensitivity, matrix effects, and cleanup level requirements. Some MDLs vary based upon individual laboratories, methods, and matrices. Table 11.8 illustrates typical MDLs. Contracts with laboratories will specify analytes, methods, and limits required to meet requirements detailed within the FSP.

Table 11.6 Field Measurement Parameters

	Analysis
Sample type	**Field measurements or laboratory analysis**
Environmental samples	High purity Ge detector
Waste characterization samples	None [a]

[a] For additional information, refer to the WMP, Chapter 13.

Table 11.7 TCL/TAL Parameters

Volatiles		
2-Butanone	Acrylonitrile	Ethyl methacrylate
2-Chloroethyl vinyl ether	Benzene	Iodomethane
2-Hexanone	Bromodichloromethane	M,p-xylene
4-Methyl-2-pentanone	Bromoform	Methylene chloride
Acetone	Bromomethane	o-xyleneDibromomethane
1,1,1-Trichloroethane	Carbon disulfide	Styrene
1,1,2-Trichloroethane	Carbon tetrachloride	Tetrachloroethene
1,1,2,2-Tetrachloroethane	Chlorobenzene	Toluene
1,2,3-Trichloropropane	Chloroethane	trans 1,3 Dichloropropene
1,1-Dichloroethane	Chloroform	trans-1,2-Dichloroethene
1,1-Dichloroethene	Chloromethane	trans-1,3-Dichloropropene
1,2-Dibromomethane	cis-1,3-Dichloroprene	trans-1,4-Dichloro-2-butene (100)
1,2-Dichloroethane	cis-1,3-Dichloropropene	Trichloroethene
1,2-Dichloroethene (total)	Dibromochloromethane	Trichlorofluoromethane
1,2-Dichloropropane	Dichlorodifluoromethane	Vinyl acetate
Acrolein	Ethyl benzene	Vinyl chloride

Table 11.7 TCL/TAL Parameters (continued)

Semivolatiles		
1,2,4-Trichlorobenzene	4-Chloroaniline	Dibenzofuran
1,2-Dichlorobenzene	4-Chloro-3-methylphenol	Diethyl phthalate
1,3-Dichlorobenzene	4-Chlorophenyl-phenyl ether	Dimethyl phthalate
1,4-Dichlorobenzene	4-Methylphenol	Di-n-butyl phthalate
2,4,5-Trichlorophenol	4-Nitroaniline	Di-n-octyl phthalate
2,4,6-Trichlorophenol	4-Nitrophenol	Fluoranthene
2,4-Dichlorophenol	Acenaphthene	Fluorene
2,4-Dimethylphenol	Acenaphthylene	Hexachlorobenzene
2,4-Dinitrophenol	Anthracene	Hexachlorocyclopentadiene
2,4-Dinitrotoluene	Benzo(a)anthracene	Hexachloroethane
2,6-Dinitrotoluene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene
2-Chloronaphthalene	Benzo(b)fluoranthene	Isophorone
2-Chlorophenol	Benzo(g,h,i)perylene	Naphthalene
2-Methylnaphthalene	Benzo(k)fluoranthene	Nitrobenzene
2-Methylphenol	Benzyl Alcohol Butylbenzylphthalate	N-nitroso-di-n-propylamine
2-Nitroaniline	bis(2-Chloroethyl)ether	N-Nitrosodiphenylamine
2-Nitrophenol	bis(2-Chloroethyoxy)methane	Pentachlorophenol
3,3'-Dichlorobenzidine	bis(2-Ethylhexyl)phthalate	Phenanthrene
3-Nitroaniline	Chrysene	Phenol
4,6-Dinitro-2-methylphenol	Dibenz(a,h)anthracene	Pyrene
4-Bromophenyl-phenylether		
PCBs		
Aroclor-1016	Aroclor-1242	Aroclor-1254
Aroclor-1221	Aroclor-1248	Aroclor-1260
Aroclor-1232		
Metals		
Aluminum	Manganese	Silver
Arsenic	Mercury	Thallium
Beryllium	Molybdenum	Uranium
Cadmium	Nickel	Vanadium
Chromium	Selenium	Zinc
Iron		

TCL = Target Compound List
TAL = Target Analyte List

Table 11.8 Method Detection Limit for Nuclear Regulatory Commission-Licensed Laboratory Analyses

Soil (μg/kg)		**TCL volatiles[a] SW-846,[b] 8260**	
10	Benzene	1,1-Dichloroethane	Tetrachloroethene
	Bromodichloromethane	1,2-Dichloroethane	Toluene
	Bromoform	1,1-Dichlorethene	trans-1,2-Dichloropropene
	Carbon disulfide	cis-1,2-Dichloroethene	trans-1,4-Dichloro-2-butene (100)
	Carbon tetrachloride	1,2-Dichloropropane	1,1,1-Trichloroethane
	Chlorobenzene	Ethyl methacrylate	1,1,2-Trichloroethane
	Chloroform	Ethyl benzene	Trichloroethene
	cis-1,3-Dichloroprene	Iodomethane	Trichlorofluoromethane
	trans-1,3-Dichloropropene	Methylene chloride	1,2,3-Trichloropropane
	cis-1,3-Dichloropropene	Styrene	trans-1,2 Dichloroethene
	Dibromochloromethane	Dichlorodifluoromethane	*m,p-* xylene (20 ug/kg)
	Dibromomethane	1,1,2,2-Tetrachoroethane	*o-* xylene
	1,2-Dibromomethane	1,1,1,2-Tetrachloroethane	Chloromethane
	Bromomethane	2-Chloroethyl vinyl ether	Vinyl chloride
	Chloroethane	2-Butanone	Vinyl acetate
	4-Methyl-2-pentanone	Acrolein	2-Hexanone
	Acetone	Acrylonitrile	
Soil (μg/kg)		**TCL semivolatiles SW-846, 8270**	
660	Acenapthene	Dibenzo(a,h)anthracene	Isophorone
	Acenaphthylene	Dibenzofuran	2-Methylnaphthalene
	Anthracene	1,2-Dichlorobenzene	2-Methylphenol (o-cresol)
	Benzo(a)anthracene	1,3-Dichlorobenzene	4-Methylphenol (p-cresol)
	Benzo(b)fluoranthene	1,4-Dichlorobenzene	Naphthalene
	Benzo(k)fluoroanthene	2,4-Dichlorophenol	Nitrobenzene
	Benzo(a)pyrene	Diethylphthalate	2-Nitrophenol
	Benzo(g,h,i)perylene	2,4-Dimethylphenol	N-Nitroso-di-n-dipropylamine
	bis(2-Chloroisopropyl)ether	Dimethylphthalate	N-Nitrosodiphenylamine
	bis(2-Chloroethoxy)methane	2,4-Dinitrotoluene	Phenanthrene
	bis(2-Chloroethyl)ether	2,6-Dinitrotoluene	Phenol
	bis(2-Ethylhexyl)phthalate	Fluoranthene	Pyrene
	4-Bromophenyl-phenylether	Fluorene	1,2,4-Trichlorobenzene
	Butylbenzylphthalate	Hexachlorobenzene	2,4,5-Trichlorophenol
	2-Chloronaphthalene	Hexachlorobutadiene	2,4,6-Trichlorophenol
	2-Chlorophenol	Hexachlorocyclopentadiene	4-Chlorophenyl-phenylether
	di-N-butylphthalate	Hexachlorethane	Chrysene
	di-N-octylphthalate	Indeno(1,2,3-cd)pyrene	
1300	Benzyl alcohol	4-Chloroanaline	3,3-Dichlorobenzidine
	4-Chloro-3-methylphenol		
Soil (μg/kg)		**TCL semivolatiles SW-846, 8270**	
3300	Benzoic acid	2-Nitroanaline	4-Nitrophenol
	4,6-Dinitro-2-methylphenol	3-Nitroanaline	Pentachlorophenol
	2,4-Dinitrophenol	4-Nitroanaline	
Soil (mg/kg)		**TCL PCBs SW-846, 8082**	
0.1	Aroclor-1016	Aroclor-1242	Aroclor-1254
	Aroclor-1221	Aroclor-1248	Aroclor-1260
	Aroclor-1232		

Table 11.8. Method Detection Limit for Nuclear Regulatory Commission-Licensed Laboratory Analyses (continued)

Soil (mg/kg)	TAL metals[b]	Method SW-846, 6010, 6020, and 7000 series
10	Aluminum	6010
0.5	Beryllium	6010
	Chromium	6010
20	Iron	6010
2.5	Manganese	6010
	Molybdenum	6010
5	Nickel	6010
2.5	Silver	6010
2.5	Vanadium	6010
1	Uranium	6010
20	Zinc	6010
1	Arsenic	6020
2	Cadmium	6010
1	Selenium	6010
2	Thallium	6020
0.02	Mercury	6010
Soil (pCi/g)	**Radionuclides**	**Method**
5	Gross alpha	EPA-900
5	Gross beta	EPA-900
3	Uranium-234	Alpha Spec[c]
2	Uranium-235	Alpha Spec[c]
2	Uranium-238	Alpha Spec[c]
8	Technetium-99	Liquid Scintillation [c]
3	Thorium-228	Alpha Spec[c]
4	Thorium-230	Alpha Spec[c]
3	Thorium-232	Alpha Spec[c]
3	Neptunium-237	Alpha Spec[c]
6	Plutonium-238	Alpha Spec[c]
4	Plutonium-239/240	Alpha Spec[c]
3	Americium-241	Alpha Spec[c]
0.5	Cesium-137	Gamma Spec[c]

[a]*Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* SW-846 (EPA 1994). Values shown in this table are taken from this document and presented therein as both MDLs and practical quantitation limits.
[b]SW-846, Methods 7470 and 7471 will be used to analyze for mercury in water and soil, respectively.
[c]This procedure is derived from a variety of sources including, but not limited to, *Environmental Measurements Laboratory Procedures Manual* (HASL-300) (DOE 1982). Equivalent laboratory methods may be used for radiological analyses if the laboratory standard operating procedures have been approved by DOE.-
MCL = Maximum contaminant level
TCL = Target Compound List
MDL = Method detection limit
EPA = U.S. Environmental Protection Agency
TAL = Target Analyte List
KDEP = Kentucky Department for Environmental Protection

If samples are shipped to an off-site laboratory, the project team will need to meet DOT shipping and handling regulations. Gross alpha and gross beta screenings of all samples will be performed. Analytical sample volume, holding times, and sample containers are provided in Table 11.9. Analytical methods and sample requirements for environmental samples are provided in Table 11.10.

Table 11.9 Analytical Methods and Sample Requirements for Field Screening Samples

Parameter	Method no.	Matrix	Holding time	Detection limit	Container	Preservation
High-purity Ge detector	EPA 900	Soil	6 months	5 pCi/g	None	None
Gross alpha and gross beta	EPA 900	Wipe	6 months	5 pCi/g	None	None

Table 11.10 Analytical Methods and Sample Requirements for Environmental Samples

Parameter	Method no.	Matrix	Holding time (from time of collection)	Sample container	Preservative
TCL Volatile Organics	SW-846[a], 8021, 8260 Prep 5030	Soil	14 days	4-oz. wide-mouth glass jar with Teflon-lined closure or brass liner	Cool to 4 °C
	SW-846[a], 8021, 8260 Prep 5030	Water	14 days	40 mL glass vials with Teflon-lined closure	HCl , pH < 2, Cool to 4 °C
TCL Semivolatile Organics	SW-846[a], 8270 Prep 3550	Soil	7 days extraction/40 days analysis	8-oz. wide-mouth glass jar with Teflon-lined closure or brass liner	Cool to 4 °C
	SW-846[a], 8270 Prep 3550	Water	7 days extraction/40 days analysis	1 L amber Boston Round	Cool to 4 °C
Total PCBs	SW-846, 8082	Soil	7 days extraction/40 days analysis	8-oz. wide-mouth glass jar with Teflon-lined closure or brass liner	Cool to 4 °C
	SW-846, 8082	Water	7 days extraction/40 days analysis	1 L amber Boston Round	Cool to 4 °C
TAL Metals[b]	SW-846, 6010, 6020, and 7000 series*	Soil	180 days (28 days for Mercury)	8-oz. wide-mouth glass jar with Teflon-lined closure or brass liner	Cool to 4 °C
	SW-846, 6010, 6020, and 7000 series*	Water	180 days (28 days for Mercury)	500 mL high-density polyethylene	HNO_3, pH < 2, Cool to 4 °C
Gross Alpha and Beta	No method for soil; lab specific	Soil	6 months	500-ml straight side	Cool to 4 °C
	No method for soil; lab specific	Water	6 months	500-ml straight side	Cool to 4 °C
Radionuclides	Lab specific	Soil	6 months	500-ml straight side	Cool to 4 °C
	Lab specific	Water	6 months	500-ml straight side	Cool to 4 °C

[a] EPA 1994. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Second Edition, Final Update II, SW-846, September.
[b] American Society for Testing and Materials (1991), Annual Book of ASTM Standards.
°C = degrees Centigrade
EPA = U.S. Environmental Protection Agency
HCl = hydrochloric acid
HNO_3 = nitric acid
TAL = Target Analyte List
TCL = Target Compound List

11.9.2 Field Laboratory Analytical Procedures

The analytical procedures for the field screening analysis of radionuclides will be a DOE Prime Contractor-approved procedure. The specific target compounds to be analyzed either by the field or laboratory instrumentation with detection limits are shown in Table 11.11.

Table 11.11 Target Compounds and Detection Limits for the Field Laboratory

	Detection limits	
Target Compound	**Soil**	**Water**
High purity Ge detector	10 µg/kg [a]	10 µg/kg [a]

[a] Actual detection limits will be determined based on field instrumentation chosen by the DOE Prime Contractor.

11.10 DATA REVIEW AND REPORTING

The data reduction, validation, assessment, and reporting for the investigation will be performed in accordance with DOE Prime Contractor-approved procedures. To ensure that data management activities provide an accurate and controlled flow of data generated by the laboratory, it is important that the following data handling and reporting steps be defined and implemented.

11.10.1 Data Reduction

Field program data will be produced by means of visual observation, direct-reading instrumentation, and measuring devices. All field activities, direct-reading instruments, and measuring devices will occur or be used in accordance with the SOPs and the specifications in the manufacturers' operations and maintenance manuals, as appropriate.

To present field data in a report, the data recorded in field logbooks and forms will need to be summarized and transferred to tables, figures, maps, or logs. To analyze data, some data will need to be entered into computer databases or onto spreadsheets. The FTM and other team members are responsible for data transfer activities pertinent to their roles on the project. The Sample Management/Data Coordinator will ensure that data transfers to the Paducah PEMS are performed accurately. Initially, 100% of the transfer activities will be checked. After the first two satisfactory transfers, 20% of the transfer activities will be checked. Data generated by the laboratory will be reduced using the format specified by EPA or other standard methods. The analytical data will be checked for completeness and reasonableness. Laboratory data will be reconciled with field identifiers and will be transferred from the laboratory electronic data deliverable to Paducah PEMS.

It will be the responsibility of the Sample Management/Data Coordinator to ensure that all data transferred to tables, spreadsheets, logs, maps, figures, or into Paducah PEMS are transferred correctly. All copies (paper and electronic) of data transferred will be checked at least once for completeness and accuracy. All computer programs used to analyze or reduce data will be checked at least once with a data set of known results before the program is used to process data for any site.

11.10.2 Data Verification, Validation, And Assessment

The data review process consists of the verification, validation, and assessment of environmental measurements, waste management data, field screening data, and analytical data from the fixed-base laboratory. The data verification process determines if results have been returned for all samples, if the proper analytical and field methods have been used, if analyses were performed for the desired parameters, and if the requirements of any laboratory subcontracts have been met. The data validation process determines whether proper QC methods were used and whether the results met established QC criteria. The data assessment process determines whether data are adequate for the intended use. Any problems found during the review process are documented and resolved. Data management information/ requirements for data review are discussed in the DMIP, Chapter 12.

11.10.2.1 Data Verification

Verification of analytical data can be broken down into two steps, (1) laboratory contractual screening and (2) electronic Paducah PEMS verification. Laboratory contractual screening is the process of evaluating a set of data against the requirements specified in the analytical SOW to ensure that all requested information is received. The contractual screening includes, but is not limited to, the chain-of-custody, number of samples, analytes requested, total number of analyses, method used, QC samples analyzed, electronic data deliverables (EDDs), units, holding times, and reporting limits achieved. The DOE Prime Contractor Sample Manager primarily is responsible for the screening upon receipt of data from the analytical laboratory. Electronic Paducah PEMS verification is the process for comparing a data set against a set standard or contractual requirement, specific to the project. The Sample Management/Data Coordinator performs this electronic verification. Data is flagged, as necessary, and qualifiers are stored in Paducah PEMS for transfer to Paducah OREIS.

Verification of field measurements and field screening data consists of establishing that data are recorded correctly and that field instruments have been calibrated properly, ensuring the accuracy and completeness of all field forms and logbooks (e.g., sample information forms, chain-of-custody forms, requests for samples analysis, etc.). Any problems with the data will be documented, and preventive and possible corrective actions will be taken, if necessary.

11.10.2.2 Data Validation

Data validation is the process of screening data and accepting, rejecting, or qualifying the data on the basis of sound criteria. Data validation will be performed in accordance with EPA procedures and shall be validated at a target frequency of a minimum of 10% of all data packages. DOE Prime Contractor-approved procedures regarding "Data Validation" will be used to validate the data. Data will be validated, as appropriate, based on holding times, initial calibration, continuing calibration, blank results, and other QC sample results. The process includes these steps:

- Reviewing data for compliance with contract provisions;
- Reviewing data collection and analysis methods for conformance with established criteria, such as the FSP, the QAPP, and the latest revision of the EPA SW-846 Test Methods (1994); and
- Eliminating obvious errors by checking data for proper sample identification, transmittal errors, internal consistency, and temporal and spatial consistency.

11.10.2.3 Data Assessment

The data assessment process will be performed to determine whether the total set of environmental measurements data available to the project satisfies the requirements of the project DQOs. The BGOU RI/FS Project Team will perform data assessment. The evaluation is concerned with the set of all data collected during a project or phase of a project that is intended for use in characterization, risk assessment, or remedial action decisions.

Environmental measurements data must have completed the verification and validation phases before being assessed. The verification and validation of any existing data before assessment is required whenever possible, but the validation activity may not be possible for some existing data, given previous deliverable requirements. All QC data from a project or phase of a project are reviewed to evaluate the quality of the data. The total set of data for the project is reviewed for sensitivity and PARCC parameters.

An integral component of the data assessment process is the comparison of measurement results against the DQOs to determine if the data meet or exceed the "level of certainty" required for decision-making purposes. The field and analytical results are evaluated to see if the requirements determined by the DQO process were met by the sampling and analysis activities. The DOE Prime Contractor RI Project Manager or designee makes a final determination of the usability of the data. Data qualifiers are assigned to indicate the usability of the data for meeting project requirements.

11.10.3 Data Reporting

The fixed-base laboratories are required to report data in accordance with applicable DOE Prime Contractor-approved procedures. Data deliverables will be reported in a format that fulfills the requirements of these procedures. Two copies of each data package will be required. Equivalent information in accordance with these procedures will be reported for radionuclides and other parameters in accordance with these procedures.

For this project, all laboratory analyses will include definitive deliverables. For data presented with definitive deliverables, the laboratory will provide complete Level III data packages for validation purposes.

11.11 INTERNAL QC CHECKS

SOPs are used for all routine sampling operations. Field QC sampling will be conducted to check sampling and analytical accuracy and precision for laboratory analyses of the original samples. If contaminants are found in the blanks, attempts will be made to identify the source of contamination, and corrective action will be initiated in accordance with Section 11.12.4 of this QAPP. The laboratory analyzing the samples also will include QC samples in accordance with the analytical method and the appropriate DOE Prime Contractor-approved procedures. These samples will be discussed in the laboratory QA plan.

The QC field samples and frequencies summarized in this section will be used for this task. All QC samples will be shipped according to the chain-of-custody procedures specified in the FSP. The types of QC samples used in this study are described in the following text.

11.11.1 Field QC Samples

Field QC samples will have sample numbers as described in the FSP. These samples will be analyzed for the parameters of interest; the results will be included in the analytical report.

A **trip blank** consists of a sealed container of ASTM Type II water that travels from the field to the laboratory with the samples to be analyzed for VOCs. The trip blank receives the same treatment as do sample containers; therefore, it identifies contamination that may have entered the field samples during transport. One trip blank will be placed in each cooler containing samples to be analyzed for VOCs.

A **field blank** serves as a check on environmental contamination at the sample site. Distilled, deionized water is transported to the site, opened in the field, transferred into each type of sample bottle, and returned to the laboratory for analysis of all parameters associated with that sampling event. It also is acceptable for field blanks to be filled in the laboratory, transported to the field, and then opened. Field blanks may be used as a reagent blank, as needed. Field blanks will be collected at a frequency of 1 in 20 samples (5%) for each sample matrix.

An **equipment blank or rinseate sample** is a sample of deionized water passed through, or over, decontaminated sampling equipment. Equipment blanks are used as a measure of decontamination process effectiveness and are analyzed for the same parameters as the samples collected with the equipment. Equipment blanks also may be used as reagent blanks, as needed. Equipment blanks are required only when nondisposable equipment is being used. Equipment blanks will be collected at a frequency of 1 in 20 samples (5%).

One **field duplicate** is collected for every 20 samples (5%) to determine whether the field sampling technique is reproducible. The field duplicate is collected from one sampling location, placed in a separate set of containers, and labeled with a different sample number.

A **source water blank** is a sample of the deionized and/or potable water sources used for the project. These samples are collected at the beginning of the project and monthly, if the project will be of long duration. Source water blanks are used to demonstrate that the source water is not contaminated.

11.11.2 Analytical Laboratory QC Samples

Analytical laboratory QC samples will be analyzed as required by the analytical method for the parameters of interest; the results will be included in the analytical report.

MS/matrix spike duplicate (MSD) samples require the collection of additional sample volume for aqueous samples. The laboratory splits the samples into duplicates and adds predetermined quantities of stock solutions to them before extraction and analysis. Percent recoveries are calculated to assess accuracy. Relative Percent Differences are calculated to assess analytical precision. MS/MSD samples will be analyzed at a frequency of 1 for every 20 samples (5%) for organic parameters. For inorganic parameters, a laboratory duplicate will be analyzed instead of an MSD.

11.12 AUDITS AND SURVEILLANCES

Audits and surveillances are conducted regularly by the DOE Prime Contractor QA staff to do the following:

- Check for adherence to the QA/QC requirements specified in the project documents;
- Evaluate the procedures used for data collection, data handling, and project management;
- Verify that the QA program developed for this project is being implemented according to the specified requirements;
- Verify that the laboratory is participating in a Preformance Evaluation Program;
- Assess the effectiveness of the QA program; and

- Verify that identified deficiencies are corrected.

The QA Manager is responsible for defining audits and surveillances and will perform or assign them according to a schedule that coincides with appropriate activities on the project schedule and sampling plans. Scheduled audits and surveillances may be supplemented by additional ones for any of the following reasons:

- Significant changes are made in the QAPP,

- It is necessary to verify that corrective action has been taken on a deficiency reported in a previous audit, or

- Additional audits or surveillances are requested by the DOE Prime Contractor.

11.12.1 Audits

Audits are performed in accordance with DOE Prime Contractor-approved procedures. No audits are planned for this task, though audits may be conducted at the discretion of the DOE Prime Contractor. Periodic field surveillances will be conducted.

11.12.2 Surveillances

Surveillances follow the same general format as an audit, but are less detailed and require a less formal report. A surveillance is designed to give project staff rapid feedback concerning QA compliance and facilitate corrective action.

For this project, one field surveillance is planned shortly after field mobilization. Additional field surveillances will be conducted at critical milestones. The following are example activities and documentation that may be subject to surveillance:

- Sampling

- Decontamination

- Chain-of-custody

- Field documentation

- Field training records

- Equipment calibration

- Field QC procedures

QA surveillances will be performed in accordance with a DOE Prime Contractor-approved procedure. Problems identified during surveillances will be documented, resolved, and closed in accordance with a DOE Prime Contractor-approved procedure. A DOE Prime Contractor-approved procedure will be used for nonconformances determined to be significant conditions adverse to quality. The QA Manager or QA Specialist may schedule other periodic surveillances. The QA Specialist will provide results of the surveillances to the DOE Prime Contractor RI Project Manager.

11.12.3 Nonconformances

Nonconforming items, services, or processes will be identified, controlled, and reported in accordance with a DOE Prime Contractor-approved procedure. Subcontracting personnel initiate a nonconformance report by completing a Nonconformance Report (NCR), similar to that shown in Figure 11.2. Nonconforming equipment immediately will be labeled or tagged and segregated. If it is not possible to segregate the nonconforming item, due to the item's being part of a larger piece of conforming equipment or due to other field conditions, the nonconforming item will be labeled or tagged and will not be used.

11.12.4 Corrective Action

Each project team member is responsible for notifying the FTM, the RI Project Manager, the QA staff, or other responsible persons if he/she discovers a condition that may affect the quality of the work being performed. The following staff members have specific corrective action responsibilities:

- ER Manager—Overall responsibility for implementing corrective actions.
- QA Manager—Overall responsibility for tracking and accepting corrective actions.
- RI Project Manager—Implementing task-specific corrective actions.
- FTM—Identifying and implementing corrective actions during field activities, and notifying the Project Manager and QA staff of conditions not immediately corrected.
- Sample Manager—Identifying and implementing corrective action during analysis, and notifying the RI Project Manager and QA Specialist when applicable acceptance criteria or DQOs are not satisfied.

NONCONFORMANCE REPORT	DATE OF NCR	NCR NUMBER
	LOCATION OF NONCONFORMANCE	PAGE____OF ____
INITIATOR (NAME/ORGANIZATION/PHONE)	FOUND BY	DATE FOUND
RESPONSIBLE ORGANIZATION / INDIVIDUAL		PROGRAM
		PROJECT

DESCRIPTION OF NONCONFORMANCE

CATEGORY ___ ___ ___ ___ ___

A INITIATOR: DATE

QA/QC OFFICER DATE CAR REQ'D YES ☐ NO ☐

DISPOSITION:

PROBABLE CAUSE:

ACTIONS TAKEN TO PREVENT RECURRENCE:

B PROPOSED BY: NAME DATE

JUSTIFICATION FOR ACCEPTANCE

C INITIATOR: NAME DATE

VERIFICATION OF DISPOSITION AND CLOSURE APPROVAL

REINSPECTION/RETEST REQUIRED YES ☐ NO ☐ IF YES; DATE RESULT

D QUALITY ASSURANCE: NAME DATE

Figure 11.2. Example Nonconformance Report Form

Immediate corrective actions will be noted in task notebooks. Problems not immediately corrected will require formal corrective action.

11.13 PREVENTATIVE MAINTENANCE

Periodic preventive maintenance is required for all sensitive equipment. Specific field equipment preventive maintenance practices and frequencies are described in the factory manual for each instrument. Preventive maintenance procedures for laboratory equipment and instruments are provided in laboratory QA plans. All maintenance activities will be recorded in maintenance logs. Laboratories will be required to maintain an adequate inventory of spare parts and consumables to prevent downtime, as a result of minor problems.

11.14 RECONCILIATION WITH USER REQUIREMENTS

The precision, accuracy, and completeness parameters are quantitative tools by which data sets can be evaluated. These parameters can help ensure that DQOs are met. Procedures for assessing them are provided in the following text.

11.14.1 Precision

To determine the precision of the laboratory analysis, the laboratory performs a routine program of replicate analyses in accordance with the analytical method requirements. The results of replicate analyses are used to calculate the relative percent difference, which is used to assess laboratory precision.

$$Relative\ Percent\ Difference = \frac{\left| C_1 - C_2 \right|}{\left| C_1 + C_2 \right| 2} \times 100$$

For replicate results C_1 and C_2:

where:

C_1 = original environmental sample

C_2 = replicate sample.

The precision of the total sampling and analytical measurement process will be assessed based on field duplicates. Although a quantitative goal cannot be set due to field variability, the project team will review field duplicate, relative percent difference values to estimate precision.

11.14.2 Accuracy

To determine the accuracy of an analytical method and/or the laboratory analysis, a periodic program of sample spiking is conducted (minimum 1 spike and 1 spike duplicate per 20 samples). The results of sample spiking are used to calculate the QC parameter for accuracy evaluation, the percent recovery (%R).

$$\%R = \frac{C_s}{C_t} \times 100$$

For surrogate spikes and QC samples:

where:

C_s = measured spiked sample concentration (or amount),

C_t = true spiked concentration (or amount).

$$\%R = \frac{\left| C_s - C_o \right|}{C_t} \times 100$$

For matrix spikes:

where:

C_s = measured spiked sample concentration,

C_o = sample concentration (not spiked),

C_t = true concentration of the spike.

The accuracy of the total sampling and analytical measurement process will not be determined because such a determination would require the addition of chemical spiking compounds to the samples in the field.

11.14.3 Completeness

To determine the completeness of data, the percentage of valid, viable data obtained from a measurement system is compared with the amount expected under normal conditions. The goal of completeness is to generate a sufficient amount of valid data to satisfy project needs. There also should be an evaluation of the data against the DQOs to determine if goals were met with the data collected.

Completeness (C) is calculated as follows:

$$\%C = \frac{Number\ of\ valid\ measurements}{Number\ of\ total\ measurements} \times 100$$

11.15 QA REPORTS TO MANAGEMENT

All levels of the QA team are responsible for preparing QA reports, including the Monthly NCR Status Report.

The RI Project Manager will submit a monthly activity report to the DOE Prime Contractor QA Manager. Each report will summarize the following:

- NCRs issued during the reporting period,
- Status of open NCRs during the reporting period,
- Corrective actions initiated, and
- The status of corrective actions open during the reporting period.

11.16 FIELD CHANGES

Field changes must be governed and documented by control measures commensurate with those applied to the documentation of the original design.

- Major changes from approved field operating procedures or project scope, cost, or schedule will be documented on a Field Change Request Form (FCR), similar to that shown in Figure 11.3. The FTM will initiate and maintain the FCR forms.
- Each FCR form requires a status from the DOE Prime Contractor RI Project Manager before work proceeds. Weekly quality status reports serve as the mechanism for notifying the QA staff of field changes. The DOE Prime Contractor QA Manager must status changes related to quality and receive copies of field changes. Statusing by the DOE Prime Contractor RI Project Manager can be initiated, verbally, via telephone, with follow-up sign-off. In no case will a subcontractor initiate a field change that has not been appropriately statused. If a field change is proposed by the client, it will be so recorded. Copies of the FCR forms will be kept on-site until the fieldwork is complete, and then will be transmitted to the project files.
- Variances or minor changes to field operating procedures will be documented in the field logbook and included in a variance log. The variance log will be used to track the type of variance and the logbook in which the variance was reported.
- If deemed necessary, the FSP, QAPP, or other relevant documents will be revised, reviewed, accepted, and reissued with control measures commensurate with the original documents. The DOE Prime Contractor RI Project Manager must accept each FCR form before work proceeds.
- Specific additional requirements for field changes, such as required PGDP approvals, will be addressed in contractual documentation between PGDP and the Subcontractor. The DOE Prime Contractor QA Specialist must accept all field changes that impact the quality of the project before work proceeds.

11.17 INSPECTION OF MATERIALS

All project materials (i.e., sampling instruments, etc.) will be inspected prior to acceptance and use, and all records generated as a result, will be performed according to a DOE Prime Contractor-approved procedure. The procedure for conducting material inspections is summarized in the following text:

Field Change Request (FCR)

FCR NO.__________ DATE INITIATED___________

PROJECT______________________________

CONTRACT NO.__________________________

REQUESTOR IDENTIFICATION

NAME________________________ ORGANIZATION_____________ PHONE____________

TITLE________________________ SIGNATURE___________________________

BASELINE IDENTIFICATION

BASELINE(S) AFFECTED ○ Cost ○ Scope ○ Milestone ○ Method of Accomplishment
AFFECTED DOCUMENT (TITLE, NUMBER AND SECTION)__________________________
DESCRIPTION OF CHANGE:

JUSTIFICATION:

IMPACT OF NOT IMPLEMENTING REQUEST:

PARTICIPANTS AFFECTED BY IMPLEMENTING REQUEST:

COST ESTIMATE ($)_________ ESTIMATOR SIGNATURE_______________________________

PHONE_________________ DATE______________

PREVIOUS FCR AFFECTED ○ YES ○ NO; IF YES, FCR NO. ________________

CLIENT PROJECT MANAGER _____________________________ DATE__________

CLIENT QA SPECIALIST _________________________________ DATE ______________

SAIC H&S MANAGER SIGNATURE (IF APPLICABLE)___________________________DATE_________

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Figure 11.3. Example Field Change Request Form

- Each scheduled inspection will be assigned an inspection number.

- Checklists will be prepared for work requiring inspections. Completed checklists will be attached to the Inspection Report and become part of the record of inspection.

- All inspections will be documented on an inspection report form, similar to that shown in Figure 11.4.

- All records generated from this procedure will be collected and maintained in accordance with a DOE Prime Contractor-approved procedure.

- The FTM will inspect all incoming shipments for apparent damage, shipping documentation discrepancies, and overages or shortages. For all discrepancies noted, the FTM will initiate an NCR in accordance with a DOE Prime Contractor-approved procedure.

INSPECTION REPORT

Date of Inspection: ______________________ Inspection No.: ________________

References (include Revision/Date): _______________________________________

Activity / Item Inspected: ____

____

____

____

____

____

____

Personnel Contacted (include company, title , and phone #): ____________________

____

____

Reference To Nonconformance Report(s): ___________________________________

____

Results of Inspection: ____

____

____

Figure 11.4. Example Inspection Report Form

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12. DATA MANGEMENT IMPLEMENTATION PLAN

12.1 INTRODUCTION

The purpose of this DMIP is to identify and document data management requirements and applicable procedures, expected data types and information flow, and roles and responsibilities for all data management activities associated with the BGOU RI/FS field activities. Data management provides a system for efficiently generating and maintaining technically and legally defensible data that provide the basis for making sound decisions regarding environmental and waste characterization.

To meet current regulatory requirements for DOE environmental management projects, complete documentation of the information flow is established. Each phase of the environmental data management process (planning, collection, analysis, management, verification/validation, assessment, reporting, consolidation, and archival) must be appropriately planned and documented.

The scope of the DMIP is limited to environmental information collected during the BGOU RI/FS. This information includes electronic and/or hard copy records obtained by a project that describe environmental processes or conditions. Information generated by the project (e.g., analytical results from samples collected) and obtained from sources outside the project (e.g., historical data) falls within the scope of this DMIP. Certain types of information, such as personnel or financial records, are outside the scope of this DMIP.

12.1.1 Project Mission

The BGOU RI/FS consists of environmental sampling of media to determine the nature and extent of contamination at associated burial grounds within PGDP. This will include sampling of groundwater, soil, and sediment.

Specific activities involving data include, but are not limited to, sampling of groundwater; storing, analyzing, and shipping samples, when applicable; collection of operational and maintenance data; and evaluation, verification, validation, assessment, and reporting of analytical results.

12.1.2 Data Management Activities

Data management for the BGOU RI/FS field activities will be implemented throughout the life cycle of environmental measurements data and historical data. This life cycle occurs from the planning of data for environmental and waste characterization, through the collection, review, and actual usage of the data for decision-making purposes to the long-term storage of data. Data management activities include the following:

- Acquire existing data;
- Plan data collection;
- Prepare for field activities;
- Collect field data;

- Process field data;
- Collect field samples;
- Submit samples for analysis;
- Process laboratory analytical data;
- Verify data;
- Coordinate and perform data validation;
- Assess data;
- Consolidate, analyze, and use data and records; and
- Submit data to the Paducah OREIS.

Section 12.6.1 contains a detailed discussion of these activities.

12.1.3 Data Management Iterations

The DOE Prime Contractor Sample and Data Managers will interface with the Sample Management/Data Coordinator to oversee the use of Paducah PEMS and to ensure that data deliverables meet DOE's standards. The DOE Prime Contractor Data Manager will enter information related to the fixed-base laboratory data packages and the tracking associated with the samples once the samples have been shipped and the DOE Prime Contractor Sample Manager has verified receipt of samples. The Sample Management/Data Coordinator will load the fixed-base laboratory hard-copy data, the EDDs, and the field measurement data into Paducah PEMS. The Sample Management/Data Coordinator is responsible for data verification, data validation if applicable, and assessment and for preparing the data for transfer from Paducah PEMS to Paducah OREIS. The DOE Prime Contractor Data Manager is responsible for transferring the data from the RTL files supplied by the Sample Management/Data Coordinator to the Paducah OREIS database.

The DOE Prime Contractor Sample Manager will develop the SOW to be performed by an analytical laboratory in the form of a project-specific, laboratory SOW utilizing an SOW template populated by the Sample Management/Data Coordinator according to the sampling requirements in the work plan and QAPP (Chapter 11). Analytical methods, laboratory QC requirements, and deliverable requirements will be specified in this SOW. The DOE Prime Contractor Sample Manager will receive EDDs, perform contractual screenings, and distribute data packages. The DOE Prime Contractor Sample Manager will interact with the Sample Management/Data Coordinator to ensure that hard copy and electronic deliverable formats are properly specified and will interface with the contract laboratory to ensure that the requirements are understood and met.

The DOE Prime Contractor Sample Manager receives EDDs, performs contractual screenings, and distributes data packages. The DOE Prime Contractor Sample Manager interacts with the Sample Management/Data Coordinator to ensure that hard-copy and electronic-deliverable formats are properly specified and interfaces with the contract laboratory to ensure that the requirements are understood and met.

12.2 DATA NEEDS AND SOURCES

12.2.1 Data Types

Multiple data types will be generated and/or assessed during this project. These data types are historical data, field data, analytical data (including environmental data and waste data), and geographic information system (GIS) data.

12.2.2 Historical Data

Historical data consist primarily of analytical data. Existing and historical data will be evaluated prior to field activities (e.g., sampling, field measurements). Paducah OREIS and the Paducah OREIS Data Catalog have been queried for existing information relating to the project.

Historical data downloaded from Paducah OREIS will be available in Paducah PEMS for project team use for the duration of the project. In addition, this historical data pertaining to the areas included in the BGOU RI/FS are included, electronically, in the scoping document for reference.

12.2.3 Field Measurements

Field measurements that may be collected include field measurements of ^{238}U and PCBs for soil and sediment samples and global positioning system readings for each sample location. Field measurements may be recorded on appropriate data log sheets. The Sample Management/Data Coordinator will enter the data from these sheets, manually, into Paducah PEMS. A QC check of this data entry, that involves comparing printouts of the data in the project Paducah PEMS to the original field logbook or data log sheet, will be made by the FTM or appointed designee.

12.2.4 Analytical Data

Analytical data that will be collected for the BGOU RI/FS project includes volatile, semivolatile, radionuclide, metals, uranium, and PCB data for surface soil and sediment samples, and PCB data for storm sewer water discharge samples. Paducah PEMS will be used to plan, track, and manage the collection of all analytical data. Following completion of the appropriate data verification, validation, and assessment activities, the final data set will be uploaded from Paducah PEMS to Paducah OREIS.

12.2.5 Geographic Information System Coverage

The Paducah GIS network will be used to prepare maps to be used in data analysis of both historical and newly generated data and reporting. Coverage anticipated for use during the project is as follows:

- Stations (station coordinates will be downloaded from Paducah OREIS)
- Facilities
- Plant roads
- Plant fences
- Streams
- Topographic contours (as available from the 1990 flyover)

12.3 DATA FORMS/LOGBOOKS

Field logbooks, site logbooks, diskette logs, chain-of-custody forms, data packages with associated QA/QC information, and field forms will be assigned document control numbers and maintained according to the requirement for a satellite document management center defined in the procedure for Paducah Records Management. All field activities and records, equipment calibrations, equipment decontamination activities, health and safety-related notes, and general day-to-day field notes will be recorded in a field logbook.

Data management requirements for data log sheets and field logbooks specify that (1) sampling documentation must be controlled from preparation and initiation to completion, (2) all sampling documents generated must be maintained in a project file, and (3) modifications to planned activities and deviations from procedures shall be recorded.

Duplicates of field records will be maintained until the completion of the project according to the DOE Prime Contractor-approved procedures. The FTM will copy logbooks and field documentation periodically. The originals will be forwarded to the project files; the copies will be maintained in the field trailer. The project file will be considered the Record Copy and, as such, will be stored in fire-resistant, locked file cabinets. Electronic versions also will be stored in the project file; the originator or the original recipient of the diskette will maintain backup copies.

Records will be assigned a document number that will be consistent and recognized by the PGDP DMC, according to the DOE Prime Contractor-approved procedures.

12.3.1 Field Forms

Sample information is environmental data describing the sampling event and consists of the following: station (or location), date collected, time collected, and other sampling conditions. This information is recorded in field forms, such as logbooks, chain-of-custody forms, or sample labels.

Field chain-of-custody forms contain sample-specific information recorded during collection of the sample. This information is entered directly into Paducah PEMS by the Sample Management/Data Coordinator. The BGOU RI/FS Work Plan provides detailed information on sampling locations, types of samples, sample parameters required at each location, and the frequency of collection for samples. Any deviations from the sampling plan will be noted on the field chain-of-custody form. The Sample Coordinator will review each field chain-of-custody form for accuracy and completeness, as soon as practical, following sample collection.

An example field chain-of-custody form is shown in Figure 12.1 and will be generated from Paducah PEMS with the following information:

Information that is preprinted:	**Information that is entered manually:**
Chain-of-custody number	Sample date and time
Project name or number	Top and bottom depths and units
Sample ID number	Sample comments (optional)
Sampling location (e.g., 001-001)	
Sample type (e.g., REG = regular sample)	
Sample matrix (e.g., SO = soil)	
Analysis (e.g., ^{99}Tc)	
Sample container (volume, type)	

Sample Chain of Custody Record *Page 1 of x*

CERCLA Cell Field Investigations

Sample ID CCGTBB00-000

Date/Time Sampled

Project ID ERI01-BG-XXXX Sampler:__________

Station CCGT-BB00

LAB COC NO.: COC # LAB CODE

Turnaround 30-Day Report Only

Chain of Custody

Sample Relinquished By __________ Date/Time __________

Received By __________ Date/Time __________

Sample Relinquished By __________ Date/Time __________

Received By __________ Date/Time __________

Sample Relinquished By __________ Date/Time __________

Received By __________ Date/Time __________

COC Relinquished By __________ Date/Time __________

Received By __________ Date/Time __________

PARAGROUP Matrix: SOIL

Bottle: bottle description Preservation quantity

SOW Numbers: ERI01-xx: GEOTECHNICAL LAB

Method Name	Analyses

Miscellaneous:____________________

Figure 12.1. Example Paducah PEMS Chain-of-Custody Form

Sample forms are included throughout this work plan. These are presented for examples only. Actual forms may look different; however, actual forms generally will contain the same type of information presented as the examples.

Sample identification numbers for the BGOU RI/FS are identified in Paducah PEMS, are assigned by the Sample Management/Data Coordinator, and uniquely identify each sample. Sample labels shall contain sufficient information to identify the sample in the absence of other documentation. The label shall be directly affixed to the sample container; shall be completed with blank, water-resistant ink; and shall include the following, at a minimum:

- Project number,
- Unique sample number,
- Sample location,
- Sample media,
- Analysis to be performed,
- Sampling date and time,
- Organization collecting the sample, and
- Preservation method.

As discussed in Chapter 9, the FSP, an example of the sample numbering scheme is as follows:

sssnnnMA000

where:

sss Identifies the SWMU being investigated

nnn Identifies the sequential boring number (according to the same numbering scheme, sss-nnn identifies the location name)

M Identifies the media type (W identifies the sample as groundwater, S identifies the sample as soil)

A Identifies the sequential sample (usually "A" for a primary sample and "B" for a secondary sample)

000 Identifies the planned depth of the sample in feet bgs

12.4 DATA AND DATA RECORDS TRANSMITTALS

12.4.1 Paducah OREIS Data Transmittals

Data to be stored in Paducah OREIS will be submitted to the DOE Prime Contractor Data Manager prior to reporting. Official data reporting, as will be contained within the BGOU RI/FS or in other reports to outside agencies, will be generated from data stored in Paducah OREIS for any applicable data stored there.

12.4.2 Data Records Transmittals

Upon completion of the project, the Sample Management/Data Coordinator will forward original logbooks, field documentation, project deliverables, and Paducah PEMS to the PGDP DMC. The project files will be submitted in standard records storage boxes and will contain an index of the contents and appropriate Records Transmittal List. The files will be accompanied by a completed Material Transfer Form with a cover letter to the attention of the DOE Prime Contractor Records Manager. Environmental data will be archived by the DOE Prime Contractor Data Manager or designee.

12.5 DATA MANAGEMENT SYSTEMS

12.5.1 Paducah PEMS

Paducah PEMS is the data management system that supports the BGOU RI/FS project's sampling and measurements collection activities and the generation of Paducah OREIS RTL files. Appropriate project staff can access Paducah PEMS throughout the life cycle of the project. The project will use Paducah PEMS for the following functions:

- Initiate the project;
- Plan for sampling;
- Record sample collection and field measurements;
- Record sample shipment to the laboratory;
- Receive and process analytical results;
- Evaluate and verify data;
- Analyze and access data;
- Transfer project data (in RTL format) to Paducah OREIS; and
- Store non-Paducah OREIS data.

Paducah PEMS will be used for the project to generate sample chain-of-custody forms; manage field-generated data; import laboratory-generated data; update field and laboratory data based on data verification, validation (if applicable) and assessment; and transfer data to Paducah OREIS. Requirements for addressing the day-to-day operations of Paducah PEMS include backups, security, and interface among the DOE Prime Contractor Data and Sample Managers, the Sample Management/Data Coordinator, and the Field Team.

The DOE Prime Contractor Network Administrator will perform system backups daily. Security of Paducah PEMS and of data generated during the project data management effort is essential for the success of the project. The security precautions and procedures implemented by the data management team will be designed to minimize the vulnerability of the data to unauthorized access or corruption. Only members of the data management team will have access to the project's Paducah PEMS, the hard-copy data files, and the diskettes and tape backups. Members of the data management team have installed password-protected screen savers.

12.5.2 Paducah OREIS

Paducah OREIS is the centralized, standardized, quality assured, and configuration-controlled data management system that is the long-term repository for environmental data (measurements and geographic) for environmental management projects. Paducah OREIS is comprised of hardware, commercial software, customized integration software, an environmental measurements database, a geographic database, and associated documentation. The BGOU RI/FS will use Paducah OREIS for the following functions:

- Access to existing data,
- Spatial analysis,
- Report generation, and
- Long-term storage of project data (as applicable).

12.5.3 Oak Ridge Sample Management Office Tracker Database

The SMO Tracker database is the business management information system that manages analytical sample analyses for environmental projects within the DOE Oak Ridge Office. The SMO Tracker supports the cradle-to-grave tracking of sampling and analysis activities from the time a SOW is created in the database by the DOE Prime Contractor Sample Manager through the selection of the laboratory, to the collection and shipping of samples, to the receipt of the analytical results, and finally to invoice reconciliation. The SMO Tracker is integrated with Paducah PEMS (output from the Tracker automatically goes to Paducah PEMS and vice versa). The Data and Sample Managers utilize SMO Tracker.

12.5.4 Paducah Analytical Project Tracking System

The Paducah Analytical Project Tracking System is the business management information system that manages analytical sample analyses for all environmental projects within the Paducah Site. The Paducah Analytical Project Tracking System supplements the SMO Tracker in cradle-to-grave tracking of sampling and analysis activities. The Paducah Analytical Project Tracking System generates the SOW, tracks collection and receipt of samples by the laboratory, flags availability of the analytical results, and allows invoice reconciliation. The Paducah Analytical Project Tracking System interfaces with Paducah PEMS (output from the Paducah Analytical Project Tracking System automatically goes to Paducah PEMS).

12.6 DATA MANAGEMENT TASKS AND ROLES AND RESPONSIBILITIES

12.6.1 Data Management Task

Data management activities, initially defined in Section 12.1.2, are more fully described in this subsection.

12.6.1.1 Acquire Existing Data

The primary background data to be used for this project consist primarily of analytical data. All available historical data pertaining to the areas included in the BGOU RI/FS have been downloaded from Paducah OREIS and are presented in Appendix E.

12.6.1.2 Plan Data Collection

Other documents in this BGOU RI/FS Work Plan provide additional information for the tasks of project environmental data collection, including the FSP (Chapter 9), the ES&H Plan (Chapter 10), the QAPP (Chapter 11), and the WMP (Chapter 13). Further, a laboratory SOW will be developed with the DOE Oak Ridge SMO following concurrence with the BGOU RI/FS Work Plan.

12.6.1.3 Prepare For Field Activities

Field preparation activities are performed to ready the site for field sampling operations. The data management tasks involved in field preparation include identifying all sampling locations and preparing descriptions of these stations, developing summaries of all the samples and analyses to be conducted at each sampling location, developing field forms for capturing field data, coordinating sample shipment/delivery with off-site laboratories, and coordinating screening analyses with PGDP laboratories. The Sample Management/Data Coordinator, working with the DOE Prime Contractor Sample Manager, will conduct these activities. Sampling locations will be surveyed using a global positioning system. Sample coordinates will be transferred to the PGDP coordinate system.

The FTM and the Sample Management/Data Coordinator will coordinate data management activities with field sampling activities according to the procedure for Data Management Coordination.

The Field Manager reviews field forms for the collection of sampling information for completeness. The field forms also will specify the appropriate type of information for each field. Copies of field forms will be numbered sequentially, and the number will be tracked in the field logbooks.

12.6.1.4 Collect Field Data

Paducah PEMS will be used to identify, track, and monitor each sample and associated data from point of collection through final data reporting. The tracking system for the project will include field logbooks, field forms, chain-of-custody records, and hard-copy data packages, as well as EDDs.

Data management requirements for field logbooks and field forms specify that (1) sampling documentation must be controlled from preparation and initiation to completion, (2) all sampling documents generated must be maintained in a project file, and (3) modifications to planned activities and deviations from procedures shall be recorded. Field data documentation shall be maintained according to satellite document management center requirements outlined in the procedure for Paducah Records Management.

A comprehensive sampling list is developed by the FTM and Sample Management/Data Coordinator and used as the basis for finalizing the sample containers to be used for sample collection, ordering sufficient amount of containers and other supplies, and verifying the numbers of samples presented in the laboratory SOW. Before the start of field sampling, the Sample Management/Data Coordinator will specify the contents of sample kits, which will include sample containers, labels, preservatives, chain-of-custody records, and instructions for collecting samples. Samples labels will be completed according to procedures stated in the FSP and in Section 12.3.1.

12.6.1.5 Process Field Data

Field measurements will be recorded on appropriate field forms or in field data compilers. These forms will be checked against the field logbooks, and the data will be manually entered into Paducah PEMS using the procedure for Data Entry.

12.6.1.6 Collect Field Samples

The field team will collect samples for the project. The field team will record pertinent sampling information on the chain-of-custody, along with maintaining a field logbook. The Sample Management/Data Coordinator, according to the procedure, will manually enter information from the chain-of-custody forms and field forms into Paducah PEMS for data entry.

12.6.1.7 Submit Samples for Analysis

Before the start of field sampling, the FTM and Sample Management/Data Coordinator will coordinate the delivery of samples and the receipt of results with the DOE Prime Contractor Sample Manager, who, in turn, will coordinate with the contract laboratories. The Sample Management/Data Coordinator and the DOE Prime Contractor Sample Manager will present a general sampling schedule to the off-site laboratories. The Sample Management/Data Coordinator also will coordinate the receipt of sample shipments and containers with the laboratories, and determine any requirements for laboratory permission to ship. The DOE Prime Contractor Sample Manager will ensure that hard-copy deliverables and EDDs, from the laboratories, contain the appropriate information and are in the correct formats.

12.6.1.8 Process Laboratory Analytical Data

Data packages and EDDs received from the laboratory will be tracked, reviewed, and maintained in a secure environment. Paducah PEMS will be used for tracking project-generated data. The primary individual responsible for these tasks will be the DOE Prime Contractor Sample Manager. The following information will be tracked, as applicable: sample delivery group number, date received, number of samples, sample analyses, receipt of EDD, and comments. The DOE Prime Contractor Sample Manager will compare the contents of the data package with the chain-of-custody form and identify discrepancies. Discrepancies will be reported immediately to the laboratory and the Sample Management/Data Coordinator. Copies of the Form I's from the data package will be distributed to the Sample Management/Data Coordinator.

To evaluate the quality of laboratory EDDs, the first two EDDs from each laboratory will be 100% checked against the hard-copy data packages. After the first two EDDS from each laboratory are checked, every fifth EDD will be 100% checked. The results from the EDD will be checked, as will the format of all fields provided. The Sample Management/Data Coordinator will report immediately any discrepancies to the DOE Prime Contractor Sample Manager, so that the laboratory can be notified and EDDs can be corrected.

12.6.1.9 Verify Data

The Sample Management/Data Coordinator is responsible for ensuring that data verification occurs as outlined in the procedure for Quality Assured Data. Data verification processes for laboratory data will be implemented for both hard-copy data and EDDs. The data packages will be reviewed to ensure that all samples receive the analyses requested. Discrepancies will be reported to the laboratory. Electronic data verification of the EDDs will be performed as data are loaded into Paducah PEMS. The hard-copy will be checked to ensure that requested parameters, indeed, were analyzed for; those missing from the EDD will be requested from the laboratory. Integrity checks in Paducah PEMS also will review the results generated by the laboratory to ensure that data for all requested parameters have been provided. Discrepancies will be reported to the DOE Prime Contractor Sample Manager. Additional information relating to Data Verification is included in the QAPP (Chapter 11).

12.6.1.10 Validate Data

The Sample Management/Data Coordinator is responsible for coordinating data validation. Data validation will be performed on 100% of the selected data packages. Validation will be performed on a minimum of 10% of the environmental data collected. Validators not associated with the project will perform validation following DOE Prime Contractor-approved procedures for data validation. Additional information relating to data validation is included in the QAPP (Chapter 11). A validation SOW is generated specifying the requirements for the validation of the data. Validation qualifiers are input and stored in Paducah PEMS and transferred with the data to Paducah OREIS.

12.6.1.11 Assess Data

Data assessment will be conducted and documented by a technical reviewer in conjunction with other project team members, according to the DOE Prime Contractor-approved procedure for Quality Assured Data. Data assessment follows data verification and data validation (if applicable) and must be performed at a rate of 100% to ensure data are useable. The data review process determines whether a set of data satisfies the data requirements defined in the project-scoping phase and assures that the type, quality, and quantity of data are appropriate for their intended use. It allows for the determination that a decision (or estimate) can be made with the desired level of confidence, given the quality of the data set. This process involves the integration and evaluation of all information associated with a result.

Data review consists of an evaluation of the following: data authenticity, data integrity, data usability, outliers, and PARCC parameters. Additional requirements for data assessment and review are included in the QAPP (Chapter 11).

Assessment qualifiers are stored in Paducah PEMS and transferred with the data to Paducah OREIS. Data are made available for reporting upon completion of the data assessment, and associated documentation is stored with the project files.

12.6.1.12 Consolidate, Analyze, and Use Data and Records

The data consolidation process consists of the activities necessary to prepare the evaluated data for the users. The main users of the project data are the project team, which uses the data to document the installation of the temporary borings, to document and interpret the field and analytical data from the groundwater samples, to document the installation of any new MWs, and to characterize the project waste before disposal. The DOE Prime Contractor Data Manager will store the data in the Paducah OREIS database for future use.

Project reports are reports generated for the purpose of evaluating the data during the project. These reports include the status of the sampling event, reports of data compared to various criteria, such as grain size at various depths, and reports of the complete set of data. Data analysis will be documented in sufficient detail to allow re-creation of the analysis. Project reports, as defined previously, may be generated from PEMS. Official data reporting, as will be contained within the BGOU RI/FS Work Plan or in other reports to outside agencies, will be generated from data stored in Paducah OREIS, as applicable.

12.6.1.13 Submit Data to the Paducah OREIS

Upon completion of the data assessment, the Sample Management/Data Coordinator uses Paducah PEMS to generate the RTL file for Paducah OREIS. The DOE Prime Contractor Data Manager is responsible for transferring the data to Paducah OREIS.

12.6.2 Data Management Roles and Responsibilities

The following project roles are defined, and the responsibilities are summarized for each data management task described in the previous subsection. Additional roles and responsibilities are defined in the QAPP (Chapter 11) and in Section 2.1.

12.6.2.1 RI Project Manager

The RI Project Manager has total responsibility for completing an assigned project. The RI Project Manager leads the effort to define the scope of an environmental problem or facility operation. With respect to data management, this involves directing the project team in determining potential sources of existing data, identifying the study area and/or facility to be addressed by the project, and selecting the most effective data collection approach to pursue. The RI Project Manager may also be the technical contact for subcontracted project support and should ensure that the flow down of data management requirements is defined in an SOW.

12.6.2.2 Project Team

The project team consists of the technical staff and support staff (including the data management team) that conducts the various tasks required to successfully complete the project. Team members develop a conceptual model of the project site. Based on this model, they determine if more information is needed to make decisions about the site. If more sampling and analyses are needed, the team develops a work plan or FSP to acquire that information. This team provides information needed by the decision makers (i.e., stakeholders).

12.6.2.3 Project Sample Management/Data Coordinator/Data Management Team

The Sample Management/Data Coordinator is the project’s single-point of contact for interaction with other organizations and programs regarding project data management (e.g., PEMS, OREIS, QA), and may lead a team of data management specialists, depending upon the scope of the project’s data management activities. The Sample Management/Data Coordinator has the responsibility for developing and implementing the DMIP to ensure that project data management requirements are met. The Sample Management/Data Coordinator sees to it that any existing data or new project data are properly incorporated into the project’s hard-copy data record file or data base, as appropriate, and ensures that the project data are properly incorporated into Paducah OREIS, as applicable. The Sample Management/Data Coordinator must ensure that hard-copy data records are processed according to project data records management requirements as stated in the DMIP. The Sample Management/Data Coordinator also interacts with the SMO and DOE Prime Contractor support staff and is responsible for identifying and obtaining data management training for the project team.

The Sample Management/Data Coordinator also is responsible for overseeing activities of the rest of the project data management team. The project data management team is responsible for entering project information into the project data records file and/or database and ensuring that all information has been entered correctly. The data management team works with field teams to facilitate data collection and verification, and with data users to ensure easy access to the data. The Sample Management/Data Coordinator interacts with the SMO to develop project-specific laboratory SOWs. Analytical methods, detection limits, minimum detectable activities, laboratory QC requirements, and deliverable requirements are specified in the SOW. The Sample Management/Data Coordinator is responsible for working with the project data validation coordinator to ensure that analytical SOWs incorporate necessary deliverables so that data packages from the laboratory will be appropriate for verification and validation, as specified in the project's data validation plan.

12.6.2.4 Project Data Validation Coordinator

The project data validation coordinator is responsible for ensuring the development and documentation of the project data validation plan, and for implementation (when needed) of validation through the appropriate data validation procedures. The project data validation plan is the documented strategy for implementation of data validation to meet project needs, and includes approaches for verifying that analytical and field data are complete and have accurately fulfilled requested analyses and contractual requirements.

The project data validation coordinator is responsible for interfacing with the SMO concerning laboratory data package deficiencies. When data validation is performed external to the project, the data validation coordinator should prepare a validation SOW as the mechanism by which validation implementation requirements are communicated from the project to the validation organization.

The project data validation coordinator has the responsibility for ensuring that analytical and field data are validated against a defined set of criteria, (i.e., the project data validation plan) and includes evaluating associated QC samples to ensure that analyses were preformed within specified control parameters. Validation problems must be identified and appropriately resolved. Qualifiers and reason codes may be assigned to the data to indicate usability concerns.

12.6.2.5 Field Team Manager

The FTM conducts specifically defined tasks associated with a project. A task leader will supervise the field team activities for preparation and surveys of field site and facilities and field data collection. The task leader ensures that the field activities have been properly recorded in the field logbooks or data collection forms, and reviewed. Responsibilities include identifying, recording, and reporting project nonconformances or deviations. The task leader also may be the technical contact for subcontracted project support and should ensure that the flowdown of data management requirements is defined in a SOW.

12.6.2.6 Field Team

The field team consists of those individuals who perform any activities taking place in the field (e.g., inspections, monitoring, sampling, well construction, purging, equipment installation). They will be responsible for recording field activities in field logs and data sheets.

A field QA reviewer will be part of this team and is responsible for reviewing field logs to determine if all applicable procedures were followed by the field team. The field QA reviewer ensures that all samples were properly labeled, instruments were calibrated prior to taking measurements, and information was recorded correctly.

12.6.2.7 Data User

Data users typically are members of the project team who require access to project information to perform reviews and analyses or ad hoc queries of the data. The data user determines project data usability by comparing the data against pre-defined acceptance criteria and by assessing that the data are sufficient for the intended use. This person performs data reviews, as appropriate (e.g., quality checks; assessing sensitivity, PARCC parameter conformance; evaluating adherence to data quality requirements).

The data user also will be responsible for retaining any unique computer code (e.g., Statistical Analysis System code, GIS coverage) used to generate data products (e.g., tables, graphs, maps) included in project reports. This requirement ensures that data products can be reproduced in the future.

12.6.2.8 QA Specialist

The QA Specialist is part of the project team and is responsible for reviewing project documentation to determine if the project team followed applicable procedures.

12.6.2.9 DOE Prime Contractor Document Center Manager

The DOE Prime Contractor Document Center Manager is responsible for the long-term storage of project records. The Sample Management/Data Coordinator interfaces with the DOE Prime Contractor Document Center Manager and transfers documents and records in accordance with DOE requirements.

12.6.2.10 DOE Prime Contractor Data Manager

The DOE Prime Contractor Data Manager is responsible for long-term storage of project data and for transmitting data to external agencies according to the Paducah Site Data Management Plan (DOE/OR/07-1595&D1) and the Paducah Data Management Policy. The DOE Prime Contractor Data Manager ensures compliance to policies and procedures relating to data management with respect to the project. The DOE Prime Contractor Data Manager notifies the Sample Management/Data Coordinator of the availability of analytical data.

12.6.2.11 DOE Prime Contractor Sample Manager

The DOE Prime Contractor Sample Manager is responsible for contracting any fixed-base laboratory utilized during sampling activities. The DOE Prime Contractor Sample Manager also provides coordination for sample shipment to the laboratory, reviews the contractual screening section of data assessment packages, and transmits data packages to the Paducah DMC.

13. WASTE MANAGEMENT PLAN

13.1 OVERVIEW

This WMP is the primary document for management and final disposition of IDW that will be generated as a result of investigations conducted during the BGOU RI/FS. During the course of the investigation, 43 new soil borings will be installed in SWMUs involved in the BGOU RI/FS. These will be both vertical and angle borings. The new vertical borings will be installed to a depth of approximately 60 ft bgs. The angle borings will be installed at angles and depths as indicated in the FSP (Chapter 9). There will be two new MW installed to approximately 110 ft bgs during the RI/FS.

This WMP addresses the management of wastes generated on this project from the point of generation through final disposition. The BGOU RI/FS is being conducted as a part of the ER activities at PGDP, which are managed by DOE's Prime Contractor. The DOE Prime Contractor will be responsible for waste management activities associated with this project. Standard practices and procedures outlined in this WMP regarding the generation, handling, transportation, and storage of waste will comply with all DOE requirements, RCRA requirements, and the Toxic Substances Control Act (TSCA) requirements (should PCBs become an issue).

A copy of this WMP will be available on-site during fieldwork. Copies of the plan will be issued to the DOE Prime Contractor WMC, who will be responsible for daily oversight of all waste management activities and for ensuring overall compliance with the WMP.

The approach outlined in this WMP emphasizes the following objectives:

- Management of the waste in a manner that is protective of human health and the environment;
- Minimization of waste generation, thereby reducing unnecessary costs (e.g., analytical costs), and use of the permitted storage and disposal facilities that are limited in number;
- Compliance with federal, state, and DOE requirements; and
- Selection of storage and/or disposal alternative(s) for the waste.

All waste management activities must comply with this WMP, applicable procedures, the *Waste Acceptance Criteria for the Department of Energy Treatment, Storage, and Disposal Units at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, BJC/PAD-11, most recent version (subsequently referred to as BJC/PAD-11), and waste acceptance criteria (WAC) for other specific treatment, storage, and disposal facilities (TSDF) that are designated to receive the waste.

During the course of this project, additional PGDP and DOE waste management requirements may be identified. Necessary revisions to the WMP will ensure the inclusion of these additional requirements into the daily activities of waste management personnel.

13.2 CONTAINED IN/CONTAMINATED-WITH DETERMINATIONS

This WMP describes sampling and analysis of IDW from the BGOU RI/FS. The debris and media will be characterized according to heath-based standards to determine whether or not any concentrations of TCE and 1,1,1-trichloroethane (TCA) are above or below health-based levels listed in Table 13.1. If the concentrations are below the levels contained in Table 13.1, then the waste will not be deemed to contain or be contaminated-with a RCRA listed waste (based on TCE/TCA content) for the purposes of management at the site.

Table 13.1 Health-Based Levels for TCE and 1,1,1-TCA

Constituent	Concentration in solids (ppm)	Concentration in Aqueous Liquids (ppb)
TCE	39.2	81
1,1,1-TCA	2080	If aqueous liquids are below health-based level for TCE, then 1,1,1-TCA is declared below contained-in levels.

ppm = parts per million TCE = trichloroethene
ppb = parts per billion 1,1,1-TCA = trichloroethane

The sampling approach that will be used as the basis to compare contamination levels in the environmental media to the health-based levels is defined in this WMP. The WMP will be subject to regulator review and approval under the procedures outlined in Section XX of the FFA for review and approval. The results will be compared against the contained-in, health-based levels listed above, and a contained-in determination will be made. Land Disposal Restrictions apply to media and debris that no-longer contain or are no-longer contaminated with RCRA regulated waste. Because data from previous sampling events indicate that conditions for C-746-U Landfill disposal likely are to be met, those characterization efforts will be undertaken at the same time as the sampling for the required constituents.

Wastewater concentrations of 1 ppm TCE and 25 ppm 1,1,1-TCA promulgated in 401 KAR Chapter 31:010, Section 3(1)(b)4. a. and b., apply to well purge water, well sampling water, and well development water that is generated by DOE during any sampling and investigation efforts associated with the PGDP facility, provided the water is destined for treatment at an on-site wastewater treatment facility and discharged through a PGDP KPDES-permitted outfall. Waste that meets the above definitions will be excluded from the definition of hazardous waste.

13.3 WASTE PLANNING AND GENERATION

13.3.1 Waste Planning

A Waste Generation Plan (WGP) is required before commencement of BGOU RI/FS activities that will result in the generation of waste. The WGP should be developed in accordance with Appendix A of BJC/PAD-11. Items to be completed per waste stream include the following: the waste stream description; volume (in cubic feet); the type of container to be used, including the number of containers enclosed in brackets; the preliminary category; characterization method; analytes; future disposition; schedule; and comments. The information for these items is located in other sections of this work plan, in this WMP, and/or in BJC/PAD-11. The WGP must be signed by the generator, the preparer of the WGP, and the DOE Prime Contractor Waste Operations Manager. A revised WGP must be prepared if the amount of waste to be produced changes during the course of the RI/FS.

13.3.2 Waste Generation

A variety of IDW will be generated during this project, including soil cuttings and water from drilling activities in the UCRS and RGA, and residuals derived from samples collected from borings within SWMUs with known TCE/TCA contamination. As such, the wastes generated from field-related activities have the potential to contain contaminants related to known or suspected past operational or disposal practices; therefore, this waste must be stored and disposed of in accordance with applicable state and federal guidelines. Waste generated will be stored in CERCLA waste storage areas within the CERCLA area of contamination (CERCLA AOC) during the characterization period and prior to disposal. The CERCLA AOC includes the aerial extent of contiguous contamination and all suitable areas in very close proximity to the contamination, as delineated by DOE as lead agency for this project. Consistent with EPA Policy, the storage of waste within the CERCLA AOC does not trigger RCRA storage requirements (similarly, movement of waste within a CERCLA AOC does not trigger RCRA disposal requirements). However, as a best management practice, waste storage areas within the CERCLA AOC will be managed in accordance with the substantive RCRA 90-Day storage standards; the 90-Day storage restriction and the requirement to label hazardous waste will not be applied to the storage areas

If the analytical results for a sample indicates that TCE and/or 1,1,1-TCA concentrations are below the health-based levels listed in Table 13.1, the associated IDW (debris or media) will be considered to no longer contain or be contaminated-with, a listed hazardous waste and, if such waste is not characteristically hazardous, it may be disposed at the C-746-U Landfill (if the WAC is met) and managed on-site as nonhazardous waste. If the analytical result for a sample indicates that TCE and/or 1,1,1-TCA concentrations are above the health-based levels listed in Table 13.1, then associated IDW will be managed as hazardous waste with RCRA waste codes of F001, F002, and U228 upon removal from the CERCLA AOC.

The wastes will not be manifested when being moved from the field to a storage area nearby. The storage areas will comply with the substantive requirements of RCRA 90 Day Accumulation Area (90DAA). Final disposition of the materials will depend on final characterization.

In addition to TCE/TCA contaminated waste, there also is a potential to generate waste that also is contaminated with PCBs, PAHs, radionuclides, and metals, depending on the SWMU being investigated. IDW characterization also will consider these potential contaminants as well. Final disposition of the materials will depend on final characterization.

The WGP shows the estimated quantities of waste that may be generated during implementation of this task. Sections 13.3.3 through 13.3.7 of this WMP provide a brief description of each potential waste stream.

13.3.3 Personal Protective Equipment and Plastic Sheeting

PPE will be worn as specified in the ES&H Plan, Chapter 10 of this work plan, by personnel performing the field tasks during the RI/FS. This PPE will be considered to fall into the same waste classification as the materials with which it came into contact. PPE and plastic will be segregated by classification and will be labeled appropriately. In addition, plastic sheeting used to provide containment/temporary cover will be packaged and managed as part of this waste stream. An estimate of the volume of PPE and plastic sheeting to be generated is included in Table 13.2.

Disposable PPE and plastic associated with samples collected within SWMUs with suspected TCE/1,1,1-TCA contamination will be segregated, managed as CERCLA waste, and accumulated in a

CERCLA waste storage area within the CERCLA AOC, as discussed above during the analysis of associated samples and prior to the removal of the CERCLA AOC for storage, treatment, or disposal, as appropriate. If the analytical results for the associated sample indicate that TCE and/or 1,1,1-TCA concentrations are below the health-based levels listed in Table 13.1, the PPE and plastic (and any other debris) will not be considered to "contain" or be contaminated-with listed hazardous waste for purposes of management on-site and disposal; if the WAC is met, the waste will be properly disposed in the C-746-U on-site landfill. If the analytical results for the associated sample indicates that TCE and/or 1,1,1-TCA concentrations are above the health-based levels listed in Table 13.1, the PPE and plastic will be managed as hazardous waste with waste codes of F001, F002, and U228 once it is removed from the CERCLA AOC. If the waste is removed from the CERCLA AOC, it will be transferred to a hazardous waste storage, treatment, and/or disposal facility, as appropriate

PPE and plastic generated during the decontamination of sampling equipment will be accumulated in a nearby storage area until the associated waste is properly characterized. These wastes will be placed in 1A2 55-gal drums. This PPE/plastic (and any other debris) will be managed as CERCLA waste. If the analytical results from the associated samples are less than the health-based levels, the PPE and plastic will not be considered to contain or be contaminated-with listed hazardous waste for purposes of management; and, if the WAC is met, the waste will be properly disposed in the C-746-U on-site landfill.

13.3.4 Soil (Drill Cuttings)

Drilling cuttings will be generated from installation of the new borings and wells. An estimate of the volume of drilling cuttings to be generated is included in Table 13.2.

13.3.5 Miscellaneous Noncontaminated Construction Waste

DOE has implemented waste management activities for the segregation of all clean trash (i.e., trash that is not chemically or radiologically contaminated). Examples of clean trash are office paper, aluminum cans, packaging materials, and glass bottles not used to store potentially hazardous chemicals, aluminum foil, and food items. During implementation of this WMP, all clean trash will be segregated according to those guidelines and then collected and disposed of by the WMC once it has been approved for off-site disposal.

13.3.6 Well Development Water and Purge Water

Well development water and purge water will be generated from the installation and development of newly constructed MWs and borings. An estimate of the volume of these waste waters to be generated is included in Table 13.2.

Waste will be accumulated and stored until it can be processed for removal of suspended solids, as necessary. The water then will be treated at the C-612 Northwest Plume Groundwater System or other acceptable facility and discharged to a KPDES permitted outfall. The solids will be transferred to an appropriate temporary waste storage area. The solids will be classified according to the results of soil and water sample analyses.

Table 13.2 BGOU RI/FS Waste Generation Estimates

Waste stream (1)	Volume (cubic feet) (2)	Container (number) (3)	Preliminary category (4)	Characterization method (5)	Analytes (6)	Future disposition (7)	Schedule (8)	Comments (9)
Drill cuttings and DPT residuals from boring and monitoring well installations	1300 ft^3	(2) 20-yd^3 roll-offs (63) 55-gal drums	RCRA F001, F002, and U228 Off-site disposal pending Contained-In Agreement.	Two composite samples per boring	VOCs (TCE and TCA), SVOCs, metals, and total RAD	Landfill or off-site disposal pending Contained In Agreement.	TBD	
Plastic/PPE	300 ft^3	(40) 55-gal Drums	RCRA F001, F002, and U228 Off-site disposal pending Contained-In Agreement.	Process Knowledge Association with soil or water sample results	N/A	C-746-U Landfill	TBD	Plastic/PPE will be characterized by association with soil sample results and periodic radiological screens.
Decontamination, purge, and development water	1350 ft^3 (10,000 gal)	(10) 1,000-gal mobile poly containers	Wastewater RCRA F001, F002, U228 until treated and discharged.	Direct sampling	PCB, TCE, Oil and Grease, Total Res. Cl, Total P, Total Recoverable Metals, ^{99}Tc, Hardness, Dissolved and Suspended Alpha & Beta, Total U, and pH. (See Table 6 in the WMP.)	KPDES Outfall 001	TBD	Water containing high suspended solids will be filtered prior to submittal to C-612 for treatment.
Sediment and sludge from treatment of decontamination, purge, and development water	110 ft^3	(15) 55-gal Drums	RCRA F001, F002, and U228 Off-site disposal pending Contained-In Agreement.	Process Knowledge Association with soil or water samples	N/A	Off-site disposal	TBD	

Note: This table documents the packaging requirements, forecasted quantities, and characterization for the waste generated during the project. Requirements for labeling, transportation, GSA management, etc., must be followed to insure proper waste management.
TCE = trichloroethene Total P = total phosphorus Total Res. Cl = total residual chloride
GSA = generator storage area TCA = trichloroethane
SVOC = semivolatile organic compound RGA = Regional Gravel Aquifer RCRA = Resource Conservation and Recovery Act
TSD = treatment, storage, and disposal PCB = polychlorinated biphenyl pH = negative logarithm of the hydrogen-ion concentration
RAD = radiological ^{99}Tc = technetium-99 KPDES = Kentucky Pollutant Discharge Elimination System
Total U = total uranium
* Estimated based on previous sampling activities

13.3.7 Decontamination Water and Sludge

Decontamination water and sludge (soil sediments/mud) will be generated during cleaning of the drilling and sampling equipment. The expected volumes to be generated are contained in Table 13.2. The water will be collected for treatment, characterized as required, and disposed of in accordance with the KPDES permit requirements. The sludge will be dewatered using a filter press and will be properly characterized for disposal.

13.4 WASTE MANAGEMENT ROLES AND RESPONSIBILITIES

13.4.1 Waste Management Tracking Responsibilities

Waste generated during sampling activities at PGDP will require a comprehensive waste-tracking system capable of maintaining an up-to-date inventory of waste. To prevent inappropriate disposal of waste, the tracking system will document generation data and information necessary to determine the amount of contamination, if any, present in the waste, so that proper disposal methods can be used. The ultimate disposal method will be the responsibility of the DOE Prime Contractor RI Project Manager.

13.4.2 Waste Management Coordinator

The WMC will ensure that all waste activities are conducted in accordance with PGDP facility requirements and this WMP. Responsibilities of the WMC also include coordinating activities with field personnel, overseeing daily waste management operations, and maintaining a waste management logbook that contains a complete history of generated waste and the current status of individual waste containers. A designated waste operator also may complete the waste management logbook.

The WMC will ensure that procurement and inspection of equipment, material or services critical for shipments of waste to off-site treatment, storage, and disposal facilities are conducted in accordance with procedure PA-3012, Procurement and Inspection of Items Critical for Paducah Off-Site Waste Shipments. In addition, the WMC will ensure that wastes which are expected to be disposed of in the C-746-U Landfill are packaged and managed in accordance with the WAC for the landfill.

Additional responsibilities of the WMC include the following:

- Maintaining an adequate supply of labels;
- Maintaining drum inventories at sites;
- Interfacing with all necessary personnel;
- Preparing Requests for Disposal (RFDs);
- Tracking generated waste;
- Ensuring that drums are properly labeled;
- Coordinating waste disposal or transfers;
- Sampling waste containers to characterize wastes;

- Transferring characterization data to DOE Prime Contractor's Data Management Coordinator; and
- Ensuring that Generator Staging Areas (GSAs), 90DAAs, and Satellite Accumulation Areas are properly established, maintained, and closed.

The WMC or designee will update a computer-generated status sheet that can be retrieved quickly and will list all waste generated during field activities. The waste status sheet will supply the following information:

- Generation date;
- RFD number;
- Waste origination point;
- Waste type (solid or liquid);
- Description (e.g., soil, PPE, plastic);
- Quantity of waste;
- Current location of waste;
- Sampling status;
- Sampling results status;
- Resampling needed; and
- Date released to PGDP.

This status sheet will be prepared monthly or as necessary to report the status of project waste generation. Waste item container logs will be used to document each addition of waste to each container and tank.

The WMC and waste operators will perform the majority of waste handling activities. These activities will involve coordination with the DOE Prime Contractor RI Project Manager who will perform periodic inspections to verify that drums are labeled in accordance with the WMP guidelines.

The WMC will be responsible for ensuring characterization sampling of the waste in accordance with the procedures outlined in this plan. When sampling is complete, the WMC will transfer the waste into the waste holding area established for this project, if necessary. If these holding areas become full before analytical results are available, then temporary storage in a 90DAA or permitted RCRA storage location will be provided.

The WMC or designee will complete all chain-of-custody forms relating to the shipment of waste characterization samples. The chain-of-custody forms, along with the associated samples, will be transferred to the personnel responsible for packaging and delivery of the samples.

The WMC or designee will inspect the decontamination facility to ensure that waste generation is minimized to the extent possible and that the transfer of liquids to the waste holding area is arranged such that the work schedule is not delayed. If improper waste-handling activities are observed, the WMC will notify the DOE Prime Contractor RI Project Manager and temporarily stop decontamination activities. All activities not in compliance with the WMP will be identified and corrected before decontamination activities continue.

13.4.3 Coordination with Field Crews

The WMC will be responsible for daily coordination with all field crews involved in activities that generate waste. The WMC will perform daily rounds of each of the work sites to oversee the waste collection and will verify that procedures used by the field crews comply with the WMP guidelines. Any improper procedures will be documented in the waste management logbook, and instructions for proper procedures will be given to the field crews. Site visits will be documented in the field logbook.

13.4.4 Coordination with Treatment, Storage, and Disposal Facilities

The waste streams generated on the BGOU RI/FS may be managed and disposed of in a variety of ways depending on characterization and classification. The debris and media will be temporarily stored as CERCLA waste described in Section 13.3. Waste may be stored for the duration of field project and transferred for disposal within two weeks after completion of field work.

Waste that is to be shipped to an off-site TSDF must be done so in accordance with applicable DOE Prime Contractor procedures.

13.4.5 Waste Management Training

The WMC and other project personnel with assigned waste management responsibilities will be trained and qualified in accordance with DOE Prime Contractor-approved Training Position Descriptions.

13.5 TRANSPORTATION OF WASTE

The areas where the BGOU RI/FS activities will be conducted are on DOE property. Transportation of waste on DOE property will be conducted in accordance with applicable DOE, PGDP, and DOE Prime Contractor policies and procedures. In the event that it becomes necessary to transport known or suspected hazardous waste over public roads, coordination will be initiated with PGDP Security, which may result in the temporary closing of roads. Transportation of known or suspected hazardous waste on public roads will be conducted in accordance with applicable DOT regulations (CFR Title 49).

13.6 SCREENING OF ANALYTICAL SAMPLES

During the course of the RI/FS field activities, screening of samples in the field and in an on-site laboratory routinely will be performed to protect the health and safety of on-site personnel to ensure compliance with regulatory requirements.

13.6.1 Field Screening

Field screening for health and safety will be conducted during project field activities and sample collection. The field screening to be performed will incorporate the use of instrumentation to monitor for organic vapors, as well as radiation meters capable of detecting alpha and beta/gamma radioactivity. An elevated reading from field monitoring may be cause for reevaluation of current waste classification, labeling, and handling activities.

13.6.2 On-Site Laboratory Radiation Screening

A fixed-base laboratory will analyze all waste characterization samples. All samples to be shipped off-site for laboratory analysis will be screened for radiation at an on-site laboratory before shipment and will receive approval for off-site shipment.

13.7 WASTE CHARACTERIZATION, SAMPLING, AND ANALYSIS

Wastes generated from sites designated as potentially contaminated will be sampled and analyzed to characterize and classify the waste for proper handling, record keeping, transfer, storage, and disposal. Waste analyses will be performed using the EPA-approved procedures, as applicable. Analyses required for hazardous waste classification will reference EPA SW-846. Wastewater analyses will reference Clean Water Act and/or Safe Drinking Water Act procedures. QA/QC requirements and data management requirements, as specified in Chapters 11 and 12 of this document, will be followed for waste characterization sampling activities.

Characterization requirements and guidance are provided in BJC/PAD-11 and in Tables 13.3 through 13.5 of this WMP. These tables describe the analytical requirements and testing that must be evaluated. The process for evaluation is described in Section 13.7.3. The WMC will coordinate with the DOE Prime Contractor RI Project Manager and DOE Prime Contractor SMO for required analyses and guidance on collection and transfer of characterization samples to a fixed-base laboratory.

13.7.1 Waste Characterization

Based on sample analyses, existing data, or process knowledge, the waste may be classified into one of the following categories:

- RCRA-listed hazardous waste,
- RCRA characteristic hazardous waste,
- PCB waste,
- Transuranic waste (TRU),
- Low-level wastes (LLW),
- Mixed waste, or
- Nonhazardous solid waste.

Table 13.3 TCLP Parameters for Analysis of Solid IDW

Constituent	Method	Total detection limit (ppm)	Total extraction limit (ppm) (total analysis)	TCLP regulatory limit (mg/l)	TCLP detection limit (mg/l)
Arsenic	7060/6010/6020	2	60.4	5.0	0.5
Barium	6010/6020	40	1,863.8	100.0	0.2
Cadmium	6010/6020	1	19.2	1.0	0.05
Chromium	6010/6020	2	87.2	5.0	0.01
Lead	7421/6010/6020	1	79.2	5.0	0.09
Mercury	7470/6020	0.2	2.6	0.2	0.02
Selenium	7740/6010/6020	1	12.8	1.0	0.5
Silver	6010/6020	2	76.2	5.0	0.01
Benzene	8240/8260	0.005	7.5	0.5	0.005
Carbon tetrachloride	8240/8260	0.005	7.5	0.5	0.005
Chlordane	8081	0.03	0.45	0.03	0.001
Chlorobenzene	8240/8260	0.005	1,500	100.0	0.005
Chloroform	8240/8260	0.005	90	6.0	0.005
Total cresol	8270	0.33	3,000	200.0	0.1
2,4-D	8150	0.02	150	10.0	0.003
1,4-Dichlorobenzene	8270	0.33	112.5	7.5	0.1
1,2-Dichloroethane	8240/8260	0.005	7.5	0.5	0.005
1,1-Dichloroethene	8240/8260	0.005	10.5	0.7	0.005
2,4-Dinitrotoluene	8270	0.13	1.95	0.13	0.1
Endrin	8081	0.02	0.3	0.02	0.002
Hexachlorobenzene	8270	0.13	1.95	0.13	0.1
Heptachlor	8081	0.008	0.12	0.008	0.001
Hexachlorobutadiene	8270	0.33	7.5	0.5	0.5
Hexachloroethane	8270	0.33	45	3.0	1
Lindane	8081	0.008	6.0	0.4	0.001
Methyl ethyl ketone	8240/8260	0.01	3,000	200.0	0.01
Methoxychlor	8081	0.08	150	10.0	0.001
Nitrobenzene	8270	0.33	30	2.0	0.1
Pentachlorophenol	8270	1.6	1,500	100.0	0.5
Pyridine	8270	0.33	7.5	5.0	0.1
Tetrachloroethene	8240/8260	0.005	10.5	0.7	0.005
Toxaphene	8081	0.16	7.5	0.5	0.002
Trichloroethene	8240/8260	0.005	7.5	0.5	0.005
2,4,5-Trichlorophenol	8270	0.16	6,000	400.0	0.5
2,4,6-Trichlorophenol	8270	0.33	30	2.0	0.1
2,4,5-TP (Silvex)	8150	0.01	15	1.0	0.001
Vinyl chloride	8240/8260	0.01	3	0.2	0.01

TCLP = Toxic Characteristic Leaching Procedure
ppm = parts per million
IDW = investigation-derived waste

Table 13.4 Analytical Parameters for Classification of Solid IDW as TRU, LLW, or PCB Wastes

Constituent	Detection limit		Method
Total uranium	150	pCi/g	Method to be proposed by the lab and approved by the DOE Prime Contractor.
Neptunium-237	3	pCi/g	
Plutonium-239/240	3	pCi/g	
Plutonium-238	3	pCi/g	
Thorium-230/232	5	pCi/g	
Technetium-99	500	pCi/g	
Cesium-137	5	pCi/g	
Xylene	30	ug/kg	8240 or 8260
Acetone	10	ug/kg	8240 or 8260
Toluene	10	ug/kg	8240 or 8260
Isopropanol	2.5	mg/kg	3810 E3R0
PCB	0.1	NA	8082
Total cyanides	1.0	mg/kg	9010

DOE = U.S. Department of Energy TRU = transuranic
PCB = polychlorinated biphenyl LLW = low-level waste IDW = investigation-derived waste

Table 13.5 Waste Characterization Requirements for Solid IDW (Drill Cuttings/Other Soil IDW)

Constituent	Detection Limit	Method
TCLP VOCs	SW-846 1311, 8240, 8260	Before samples are collected for IDW analyses, analytical results for corresponding soil boring samples shall be compared with the values in Tables 13.2 and 13.3. If soil boring results are less than the levels in these tables, the soil IDW shall be considered non-RCRA waste (with the exception of TCE detections greater than 39.2 mg/kg) and shall require no further sampling for RCRA components. If results are greater than the levels in these tables, the soil IDW shall be considered a potential RCRA waste and shall be sampled for the parameters in this table.
TCLP SVOCs	SW-846 1311, 8270	
TCLP metals	SW-846 1311, 6010/7470	
TCLP pesticides	SW-846 1311, 8150	
TCLP herbicides	SW-846 1311, 8150	
Flash point	40 *CFR* 261.21	
Reactivity	SW-846 Section 7.3	Note: The only TCLP fractions to be analyzed for are those fractions detected in corresponding soil boring samples.
Corrosivity	SW-846 Section 7.2	
Moisture content	ASTM D2216	Note: Radioactivity values shall be provided from environmental samples collected during the drilling of soil borings or MWs.

TCLP = Toxic Characteristic Leaching Procedure TCE = trichloroethene
VOC = volatile organic compound SVOC = semivolatile organic compound
IDW = investigation-derived waste RCRA = Resource Conservation and Recovery Act
ASTM = American Society for Testing and Materials CFR = Code of Federal Regulations

13.7.1.1 RCRA-listed hazardous waste

Based on process knowledge and existing historical sample data, the generation of RCRA listed-hazardous waste is expected on this project. The waste is listed-hazardous due to the presence of TCE in the RGA underlying the majority of the area in which the soil borings and wells are to be installed. Waste generated during installation of MWs and soil borings (i.e., drilling cuttings, well development water, purge water, sample residuals), as well as all PPE, plastic, and decontamination wastes generated during this work, will be classified as listed hazardous wastes with waste codes F001, F002, and U228 if analytical results for the associated soil samples and water samples are above the health-based levels discussed in Table 13.1. If the concentrations are below the levels contained in Table 13.1, then the waste will not be deemed to contain or be contaminated-with a RCRA listed waste (based on TCE/TCA content) for the purposes of management. If the WAC is met, the waste will be properly disposed of in the C-746-U Landfill.

13.7.1.2 RCRA-characteristic hazardous waste

Based on process knowledge and existing historical sample data, the generation of RCRA characteristic-hazardous waste is not expected during this RI/FS.

13.7.1.3 PCB wastes

The waste will be classified based on threshold levels of PCB concentrations in the solid or liquid waste, not on PCB concentrations of the original source material. Waste that contains PCBs between the practical lowest level of detection in the waste matrix (i.e., 0.1 ppb in water and 1 ppm in soil) and less than 50 ppm shall be classified as PCB-detectable waste. Wastes that have PCB levels equaling or exceeding 50 ppm shall be classified as PCB waste.

13.7.1.4 TRU wastes

TRU wastes are those that are contaminated with elements that have an atomic number greater than 92, including neptunium, plutonium, americium, and curium that are in concentrations greater than 100 nCi/g. Although it is possible that TRU elements may be detected in characterization samples collected on this project, it is unlikely that any of the waste generated will be at or above the TRU threshold limit.

13.7.1.5 LLW

LLWs are described as any nonhazardous, non-PCB, or non-TRU waste containing radioactivity or other radionuclides in a concentration greater than the latest off-site release criteria and are not classified as high-level waste, TRU waste, spent nuclear fuel, or by-product material. LLW may be generated from materials removed from the Radiological Areas. All wastes have the potential to be classified as LLW for this project.

13.7.1.6 Mixed wastes

Mixed waste contains both hazardous waste and source, special nuclear, or byproduct material subject to the Atomic Energy Act of 1954." The generation of mixed waste is possible on this project.

13.7.1.7 Nonhazardous wastes

Waste that does not meet the classification requirements of RCRA hazardous wastes, PCB wastes, LLW, TRU waste, or mixed wastes will be classified as nonhazardous solid waste.

13.7.2 Sampling and Analysis of Waste

The WMC will be responsible for sampling the solid and liquid waste as needed. During sampling, all appropriate health and safety concerns will be addressed. Sample materials from different containers will not be mixed unless they are from the same waste stream, and only containers requiring further characterization will be sampled. Samples will be assigned a unique identifier. The WGP and the following text summarize the waste characterization requirements. The sampling procedures for waste characterization are described in the following text.

13.7.3 Solid Waste

For solid wastes such as drilling cuttings and sediments and sludge from waste water treatment, the analytical results for waste samples will be compared (1) to the total extraction limit values (total analysis) for RCRA classification (Table 13.3); (2) to the limits to support classification efforts for TRU wastes, LLW, and PCB wastes (Table 13.4) and (3) for media or debris, contained in/contaminated-with levels described in Section 13.2. If the total analysis results are less than the levels presented in 40 CFR Part 261.24 or in Table 13.3, then the solid waste will be considered non-RCRA waste and will require no further sampling. If the results exceed the values in the table or total analysis data are not available, the waste will be considered a potential RCRA waste and must be sampled for the Toxicity Characteristic Leaching Procedure (TCLP) parameters listed in Table 13.5. Total TCE analysis will be used to determine if the environmental media and associated debris is a listed waste. Waste with TCE detections greater than the risk-based level of 39.2 ppm will be considered hazardous waste.

Additional analyses to meet off-site disposal WAC also may be required and will be specified upon selection of the disposal site.

13.7.3.1 Aqueous waste

All liquid waste samples will be collected directly from the 55-gal drum, 1000-gal portable containers, or larger tanks, as applicable, which will be located in the secured storage area. One sample will be collected from each tank or drum when capacity is reached or fieldwork is complete.

Collecting samples from the drain valve is the preferred method, but this method will be conducted only if the drain valve is high enough from the ground to allow containment of any spilled material. Equipment for both sampling methods will be available during sampling episodes. This sample will be analyzed for oil, grease, and PCBs only. Once these results are obtained and found to be acceptable, the water will be transferred to stationary tanks and will be treated for TCE contamination and sampled further in accordance with Table 13.6. Water will also be characterized for treatment at the C-612 Northwest Plume Groundwater System or other designated facility. Following treatment, the water will be discharged through a designated KPDES outfall. One duplicate sample will be obtained for every 20 samples collected.

13.8 WASTE WATER TREATMENT

Water from the decontamination of drilling equipment will be collected, and stored as CERCLA waste. Following sampling and characterization (if required), the water will be processed to remove suspended solids, if necessary, and then transported to the C-612 Northwest Plume Groundwater System or other acceptable facility for treatment to remove the hazardous constituent TCE. Following treatment the wastewater will be discharged through a designated KPDES outfall.

Water will be transported to C-612 or other acceptable facility in mobile 1000-gal containers and will be pumped from the containers into the facility. All liquid transfers shall be conducted inside some type of secondary containment.

Table 13.6 Waste Characterization Requirements for Decontamination, Development, and Purge Water

Parameters	Methods	Detection limits and landfill classification
Oil and grease	SW-846[a], 9070	10 mg/L
Total residue chlorine (mg/L)	MCAWW[b] 330.1	NA
Total phosphorous (mg/L)	MCAWW 365.2	1.0 mg/L
Hardness (as mg/L $CaCO_3$)	MCAWW 103.1	NA
TCE (mg/L)*	SW-846, 8240 or 8260	0.0807 mg/L
1,1,1-TCA* (mg/L)	SW-846, 8240 or 8260	0.081 mg/L
PCBs	SW-846, 8082	NA
Total uranium (pCi/L)	EPA900/HASL-300[c]	30 pCi/L
Dissolved and suspended alpha (pCi/L)	EPA900/HASL-300	15 pCi/L
Dissolved and suspended beta (pCi/L)	EPA 900/HASL-300	50 pCi/L
Technetium-99 (pCi/L)	EPA 900/HASL-300	25 pCi/L
Total recoverable metals***	SW-846, 6010/6020 7000 Series	NA
Total suspended solids	EPA 160.2	NA

[a]Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (EPA 1994).
[b]Methods for Chemical Analysis of Water and Wastes (EPA 1983b).
[c]The procedure is derived from a variety of sources including, but not limited to, Environmental Measurements Laboratory Procedures Manual (DOE 1982) and Prescribed Procedures for Measurement of Radioactivity in Drinking Water (EPA 1980).
* The lowest achievable detection limit will be applied.
*** Total recoverable metals: antimony, arsenic, beryllium, cadmium, chromium, copper, iron, lead, nickel, calcium, silver, tantalum, uranium, zinc, and mercury.
EPA = U.S. Environmental Protection Agency
NA = not applicable
pH = negative logarithm of the hydrogen-ion concentration
PCB = polychlorinated biphenyl
TCE = trichloroethene

13.9 SAMPLE RESIDUALS AND MISCELLANEOUS WASTE MANAGEMENT

The SMO-approved analytical laboratory will generate sample residuals and laboratory wastes. The laboratory will manage and return listed-hazardous waste sample residuals to the project. Nonhazardous wastes will be disposed of by the laboratory if they have the appropriate resources. If not, all wastes will be returned to the project waste stream.

13.10 WASTE MINIMIZATION

Waste minimization requirements that will be implemented, as appropriate, include those established by the 1984 Hazardous and Solid Waste Amendments of RCRA; DOE Orders 5400.1, 5400.3, 435.1; and DOE Prime Contractor's requirements. Requirements specified in the DOE Prime Contractor's WMP regarding waste generation, waste tracking, waste reduction techniques, and the waste reduction program, in general, also will be implemented.

To support DOE's commitment to waste reduction, an effort will be made during field activities to minimize waste generation as much as possible, largely through ensuring that potentially contaminated wastes are localized and do not come into contact with any clean media (which could create more contaminated waste). Waste minimization also will be accomplished through waste segregation, selection of PPE, waste handling (spill control), and the use of alternative treatment standards.

Solid wastes such as Tyvek™ coveralls and packaging materials will be segregated. An attempt will be made to separate visibly soiled Tyvek™ coveralls from unsoiled ones. In some instances, partially soiled coveralls can be cut up and segregated. Other solid waste will not be allowed to contact potentially contaminated drill cuttings. Efforts will be made to keep Tyvek™ coveralls clean, reuse clean coveralls, and wear coveralls only when absolutely necessary. Proper waste handling and spill control techniques will help minimize waste, particularly around the decontamination areas where decontamination water must be contained. In addition, hoses used in the decontamination area will not be permitted to leak, which would create additional wastewater that would require disposal.

13.11 HEALTH AND SAFETY ISSUES RELATED TO WASTE ACTIVITIES

Waste management activities will be conducted in accordance with health and safety procedures documented in the ES&H Plan included as Chapter 10 of this work plan.

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14. COMMUNITY RELATIONS PLAN

BGOU RI/FS information will be included in the appropriate stakeholder-related activities as described in the *Community Relations Plan for the Environmental Management and Enrichment Facilities Program, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1998e) and any subsequent updates of the Community Relations Plan.

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APPENDIX A

ARARs

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ACRONYMS

ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
BGOU	Burial Grounds Operable Unit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COE	U.S. Army Corps of Engineers
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
Fed. Reg.	Federal Register
FS	feasibility study
KAR	Kentucky Administrative Record
MCL	maximum contaminant level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NWP	Nationwide Permit
OSHA	Occupational Safety and Health Association
PGDP	Paducah Gaseous Diffusion Plant
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
SWMU	solid waste management unit
T&E	threatened and endangered
TBC	To Be Considered
USC	United States Code
USCA	United States Code Annotated

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A.1 INTRODUCTION

Congress specified in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) § 121 (42 USCA § 9621) that remedial actions for the cleanup of hazardous substances must require a level or standard of control that attains those requirements, criteria, standards, or limitations under federal or more stringent state environmental laws that are legally applicable or relevant and appropriate (ARAR) to the hazardous substances or circumstances at a site (unless an ARAR is waived).

This appendix supplies a preliminary list of available federal and state chemical-, location-, and action-specific ARARs that may be associated with potential remedial actions at the Burial Grounds Operable Unit (BGOU) at the Paducah Gaseous Diffusion Plant (PGDP). The process of ARAR identification is an iterative one that is continually changing as the remedial investigation/feasibility study (RI/FS) progresses; therefore, the ARARs that are identified represent a compilation of potential ARARs that are subject to change as site-specific contamination at the BGOU is further characterized and alternatives are further evaluated. Site-specific ARARs will be identified further during the remedial action selection for the FS.

The U.S. Environmental Protection Agency (EPA) differentiates ARARs as either "applicable" or "relevant and appropriate" to a site. The terms and conditions of these categories are as follows:

- *Applicable requirements* are "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site" (40 CFR § 300.5); and

- *Relevant and appropriate requirements* are "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (40 CFR § 300.5).

The EPA also categorizes ARARs based on whether they are specific to the chemical(s) present at the site (chemical-specific), the remedial action being evaluated (action-specific), or the location of the site (location-specific). The EPA designated these categories to assist in the identification of ARARs; however, they are not necessarily precise [53 Fed. Reg. 51437 (1988)]. Some ARARs may fit into more than one category, while others may not definitively fit into any one category. Terms and conditions relevant to this categorization are included in the list that follows:

- *Chemical-specific ARARs* usually are "health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of numerical values" [53 Fed. Reg. 51437 (1988)]. These values establish the acceptable amount or concentration of a chemical that may remain in, or be discharged to, the ambient environment.

- *Action-specific ARARs* usually are "technology- or activity-based requirements or limitations placed on actions taken with respect to hazardous wastes, or requirements to conduct certain actions to address particular circumstances at a site" [53 Fed. Reg. 51437 (1988)]. Selection of a particular remedial action at a site will trigger action-specific ARARs that specify appropriate technologies and performance standards.

- *Location-specific ARARs* “generally are restrictions placed upon the concentration of hazardous substances or the conduct of activities solely because they are in special locations” [53 Fed. Reg. 51437 (1988)]. Some examples of special locations include floodplains, wetlands, historic places, and sensitive ecosystems or habitats.

Chemical-specific ARARs include concentration limits for contaminants such as maximum contaminant levels and Kentucky Pollutant Discharge Elimination System effluent limits. Action-specific ARARs include performance and design standards, such as the Resource Conservation and Recovery Act (RCRA) minimum technology requirements. Location-specific ARARs include regulations covering preservation of historic sites and protection of wetlands and floodplains.

Pursuant to CERCLA § 121(e) [42 U.S.C.A. § 9621(e)(1)], response actions, or portions of response actions entirely onsite, as defined in 40 CFR § 300.5, must comply with the substantive portions of ARARs, but not the procedural or administrative requirements. Additionally, CERCLA § 121(d)(4) [42 U.S.C.A. § 9621(d)(4)] provides six ARAR waiver options that may be invoked, provided that human health and the environment are protected.

Published unpromulgated information that does not necessarily meet the definition of an ARAR may be necessary, under certain circumstances, to determine what is protective of human health and the environment. This type of information is known as To Be Considered (TBC) guidance and also may be useful in developing CERCLA remedies. Because ARARs do not exist for every chemical or circumstance that may be found at a CERCLA site, the EPA believes that it may be necessary, when determining cleanup requirements or designing a remedy, to consult reliable information that otherwise would not be considered a potential ARAR. Criteria or guidance developed by the EPA, other federal agencies, or states may assist in determining, for example, health-based levels for a particular contaminant or the appropriate method for conducting an action for which there are no ARARs. The TBC guidance generally falls within four categories: (1) health effects information; (2) technical information on how to perform or evaluate investigations or response actions; (3) policy; and (4) proposed regulations, if the proposed regulation is noncontroversial and likely to be promulgated as drafted.

The EPA requires compliance with Occupational Safety and Health Association (OSHA) standards through § 300.150 of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), not through the ARARs process. Worker health and safety requirements typically are not addressed as ARARs. The regulations at 29 CFR § 1910.120 are designed to protect workers involved in cleanup operations at uncontrolled hazardous waste sites and to provide for worker protection during initial site characterization and analysis, monitoring activities, materials handling activities, training, and emergency response.

The remainder of this appendix will address those requirements that apply to remedial actions through the CERCLA (i.e., ARARs) process. As mentioned above, ARARs identification is an iterative process that continually changes as the RI/FS progresses. Contingent Based on the remedial action ultimately selected, ARARs specific to that action will be identified later in the remedial action process.

A.2 CHEMICAL-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Radionuclide contamination. Radionuclides have been detected in soil at the BGOU solid waste management units (SWMUs). While no cleanup standards currently exist for soil contaminated with radionuclides, U.S. Department of Energy (DOE) Order 5400.5 ("Radiation Protection of the Public and the Environment") specifies radiation exposure limits for members of the general public. They include an effective dose equivalent of 100 mrem/yr. The Order also requires DOE personnel and contractors to strive to ensure that radiation doses to members of the public are as low as reasonably achievable (ALARA) below the appropriate limits. The Order applies to exposure of the public as a result of routine DOE activities, including implementation of remedial actions. While all DOE facilities must comply with this Order, under the NCP it would be classified as TBC guidance for radionuclide remediation rather than applicable or relevant and appropriate since it has not been promulgated. However, the DOE is in the process of promulgating the order in the *Code of Federal Regulations* [58 Fed. Reg. 26268 (1993) (to be codified at 10 CFR § 834)]. Once promulgated, it will become an applicable requirement for remedial actions involving radionuclides at the PGDP.

Radionuclide emission standards. On-site activities involved with the implementation of any remedial action selected may produce airborne pollutants. If radionuclide emissions were to occur, emission standards for DOE facilities would apply. The regulations promulgated pursuant to the Clean Air Act of 1970, as amended by the Clean Air Act of 1990, set emission standards for radionuclides, other than radon, from DOE facilities. This regulation requires that DOE ensure that emissions from its facilities do not exceed those amounts that would cause any member of the public to receive, in any year, an effective dose equivalent in excess of 10 mrem/yr (40 CFR § 61.92). These regulations in 40 CFR § 61.92 would be applicable to any activity that would result in radionuclide emissions.

Groundwater contamination. The National Revised Primary Drinking Water Standards at 40 CFR § 141 Subpart G and the Kentucky Administrative Regulations at 401 KAR 8:250 may be relevant and appropriate for contaminated groundwater in the BGOU. The maximum contaminant levels (MCLs) defined in these regulations are legally applicable to water "at the tap," but are not applicable to the cleanup of groundwater. However, they may be potentially considered as relevant and appropriate to the remediation of groundwater at the DOE property boundary that is an actual or potential drinking water source.

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A.3 LOCATION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

No threatened or endangered species or their potential habitats, critical habitats, 100-year floodplains, wetlands, prime farmland, or cultural resources have been identified in the boundaries of the BGOU SWMUs. However, a 100-year floodplain has been identified near SWMU 4 and wetlands have been identified in the ditches south of SWMU 4 and across a roadway to the north. Wetlands also have been identified south of SWMUs 5 and 6 on the other side of a roadway (CDM 1994; COE 1994; LMES 1996). Although all ARARs discussed in this section are applicable, they will be met by avoidance of the resource. However, if impacts become apparent, due to construction or other plan modifications, additional requirements, mitigation for impacts to floodplains, and the like] will need to be addressed and/or initiated during the remedial design and/or remedial action phase to comply with the ARARs.

Construction activities must avoid or minimize adverse impacts on wetlands and act to preserve and enhance their natural and beneficial values [Executive Order 11990; 40 CFR § 6.302(a); 40 CFR § 6, Appendix A; and 10 CFR § 1022]. In addition, construction activities must minimize potential harm to the 100-year floodplain [Executive Order 11988 and 10 CFR § 1022].

40 CFR § 230.10(b) prohibits discharges of dredged or fill material that cause or contribute to violations of state water quality standards, violate toxic effluent standards or discharge prohibitions (33 USC § 1317), or jeopardize threatened and endangered (T&E) species or their critical habitat under the Endangered Species Act (16 USC § 1531, *et seq.*). If it becomes apparent that impacts to wetlands are unavoidable, the substantive requirements of 61 Fed. Reg. 65920 Nationwide Permits (NWPs), or 33 CFR § 325 (processing of general permits), and statutes governing discharges of dredged or fill material into waters of the United States would become applicable.

Specific requirements applicable to all NWPs are defined in 61 Fed. Reg. 65920 (December 13, 1996). The substantive requirements of NWP 38 (cleanup of hazardous and toxic waste) are applicable to this action, but the specific requirement of notification is not required for CERCLA actions under this NWP. Consequently, although wetlands should be delineated and avoided, the delineation does not have to be sent to the U.S. Army Corps of Engineers (COE), and the COE does not have to be notified for this action [61 Fed. Reg. 65905-65906 (1996)].

As required by 401 KAR 4:060, activities or structures exempted by 401 KAR 4:020, that includes activities covered by a COE NWP, may be placed within the regulatory floodway limit of a stream only if they are not of such nature as to result in increases in flood elevations.

No federally listed or candidate species or their habitats are known to occur in the vicinity of the project area. The Commonwealth of Kentucky has no T&E species regulations promulgated at this time. A list of plant and animal species identified for monitoring purposes is maintained by the Kentucky State Nature Preserves Commission. Impacts to the species should be considered for all DOE actions. Since the State T&E Species List has not been promulgated, it is TBC guidance.

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A.4 ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Action-specific ARARs will be developed in the FS.

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A.5 REFERENCES

CDM (CDM Federal Programs Corp.) 1994. *Investigations of Sensitive Ecological Resources Inside the Paducah Gaseous Diffusion Plant,* 7916-003-FR-BBRY, CDM Federal Programs Corporation, August 19.

COE (U.S. Army Corps of Engineers) 1994. *Environmental Investigations at the Paducah Gaseous Diffusion Plant and Surrounding Area, McCracken County, Kentucky*, United States Army Corps of Engineers, May.

DOE (Department of Energy) 1991. Draft *Summary of Alternatives for Remediation of Off-Site Contamination at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR-1013, December.

DOE 1994. *Secretarial Policy Statement on the National Environmental Policy Act*, Washington D.C., June 13.

EPA (Environmental Protection Agency) 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies (RI/FS) under* CERCLA, OWSER Directive No. 9355.3-01, Office of Solid Waste and Emergency Response, Washington DC, October.

LMES (Lockheed Martin Energy Systems, Inc.) 1996. *Wetlands Delineation For Alternate Site 2 For The UF_6 Cylinder Storage Yards, Phase IX, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-111, Lockheed Marietta Energy Systems, Inc., April.

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APPENDIX B

STATISTICAL EVALUATION METHODS

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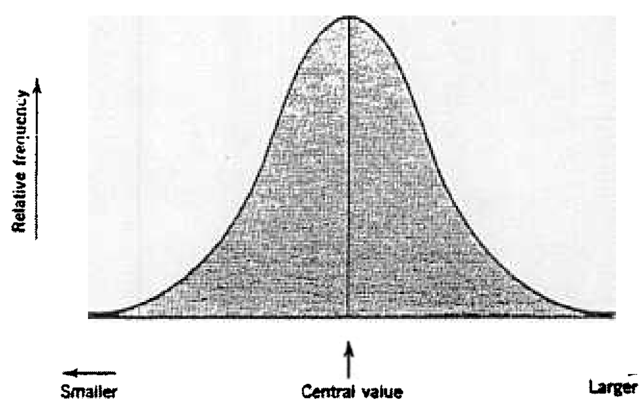
Determination of Means

The mean value of a population is defined as the sum of all observations divided by the number of observations as shown below:

$$\bar{x} \quad \frac{1}{n}\sum_{i=1}^{n} x_i$$

The mean is another word for the arithmetic average. For populations with a normal frequency distribution, the mean is located at the center with most values clustered around the mean and the frequency of occurrence decreasing away from this central point. This is shown graphically below:



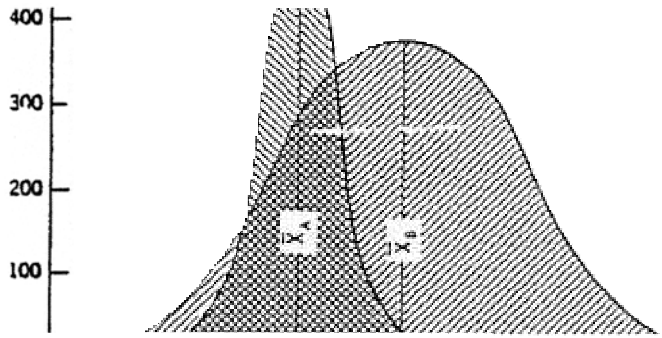
Plot of the normal frequency distribution.

The total area beneath the curve can be defined as being equal to 1.00 (or as 100% of the population distributed around the mean). The dispersion about the population mean can be expressed and standardized with respect to the mean using the normal distribution. This permits calculation of probabilities directly from the curve and allows graphic representations o£ sampling efficiency, proportionality, or range.

Methods of Measuring Dispersion

The dispersion (spread) about the me---,, while being normally distributed, is unique for every copulation. This can be shown graphically below where the dispersion around the mean of A(XA) is considerably less than the dispersion around the mean of B(XB).

\1k



While numerous methods are available for measuring the dispersion, only two methods have achieved widespread use and acceptance. They are:

1. Variance

Variance may be regarded as the average squared deviation of all possible observations from the mean of a population as defined below:

$$\sigma^2 = \frac{\sum_{i=1}^{n} (X_i - \mu)^2}{n}$$

Two algebraically equivalent forms are generally used to avoid the necessity of doing N subtractions, N multiplications, and N summations. The forms of the equation then become:

$$s^2 = \frac{\sum_{i=1}^{n} X_i^2 - n\bar{X}^2}{n-1}$$

$$s^2 = \frac{n \sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} X_i\right)^2}{n(n-1)}$$

The variance may also be calculated by using an intermediate quantity SS(the corrected sum of squares) as given below:

2. Standard Deviation

Standard deviation is defined as the square root of the variance. The advantages of using standard deviations over variance measures are:

a. The standard deviation is expressed in the units of measurement of the data.

b. The standard deviation is easily calculated from the variance.

c. The areas (expressed as a ,percentage of the total possible observations) under the curve of a normally distributed ,copulation can be precisely calculated for a given range.. That is:

(1) Standard Deviation = 68.3%
(2) (2) Standard Deviations = 95.4%
(3) (3) Standard Deviations = 99.7%
This is shown graphically below:

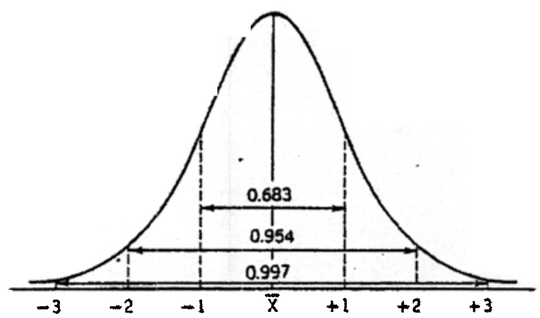


FIGURE 3.7. Areas enclosed by successive standard deviations of the standard normal distribution.

We might wish to restate o. above by relating this to a hypothetical sampling program where 100 samples were collected. First, the mean would be calculated, then by definition, the magnitudes of the first standard deviation would enclose 68 (68%) of our samples (34 on each side of the mean); 95 (95%) of our samples would be enclosed by the second standard deviation; and 5 (5%) of our samples would have-values greater than the second standard deviation and would lie outside that area.

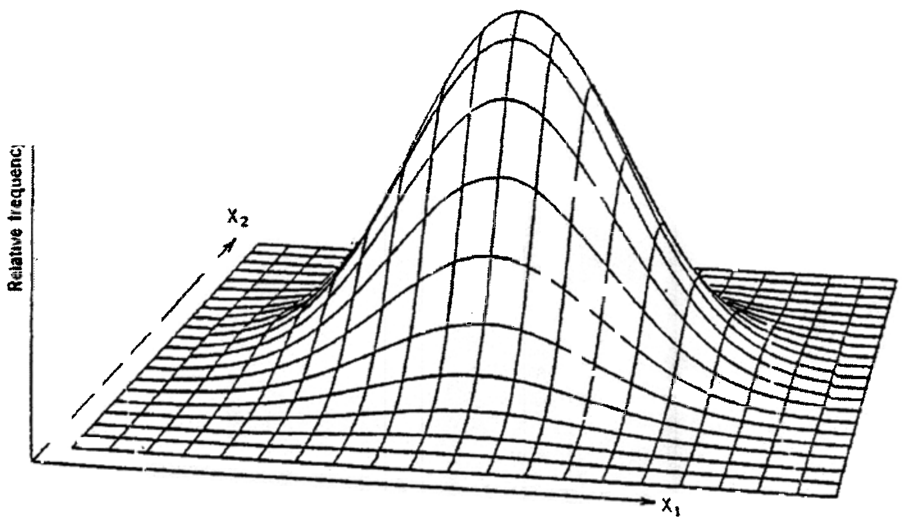
Methods of Comparing Dispersions

The comparing and testing of the properties of dispersion of two well-defined populations has been the aim of numerous statistical methods. The three methods in widespread use are:

1. Covariance

Covariance measures the joint variation of two variables about their common mean. The equation used for calculation purposes is given below:

An example of the joint variation of two variables is shown graphically below:



Joint probability distribution of two independent normal distributions. Both X_1 and X_2 are normally distributed.

Covariance results are interpreted much the same as variance results such that:

a. They may be compared against other covariance results but are not expressed in units similar to the initial measures.

b. They provide a useful intermediate quantity for inclusion in calculation of more efficient comparison methods.

2. Correlation

Correlation is the ratio of the covariance of two variables to the product of their standard deviations. The equations shown below are the definitional equation and the computational equation.

$$r_{jk} = \frac{cov_{jk}}{s_j s_k}$$

$$r_{jk} = \frac{SP_{jk}}{\sqrt{SS_j \cdot SS_k}}$$

$$= \frac{\sum_{i=1}^{n} X_{ij}X_{ik} - \left(\sum_{i=1}^{n} X_{ij} \sum_{i=1}^{n} X_{ik}\right)/n}{\sqrt{\left\{\sum_{i=1}^{n} X_{ij}^2 - \left[\left(\sum_{i=1}^{n} X_{ij}\right)^2/n\right]\right\}\left\{\sum_{i=1}^{n} X_{ik}^2 - \left[\left(\sum_{i=1}^{n} X_{ik}\right)^2/n\right]\right\}}}$$

The advantages of using correlation measures instead of covariance measures are:

a. The calculation of correlation estimates the interrelation between variables in a manner not influenced by measurement units.

b. Because the correlation is a ratio, it is a unitless number. However, it has definite range (between +1.00 and -1.00) which may equal but not exceed the product of the standard deviation of its variables.

c. The magnitude and sign of the correlation (hereinafter called the. correlation coefficient) can be interpreted as follows

(1) positive correlation coefficient - direct relationship between variables

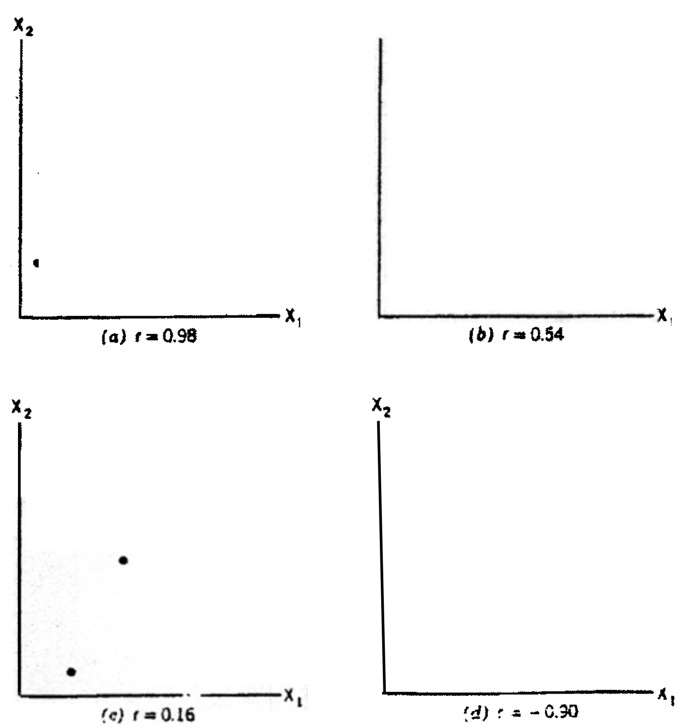
(2) negative correlation coefficient - inverse relationship between variables

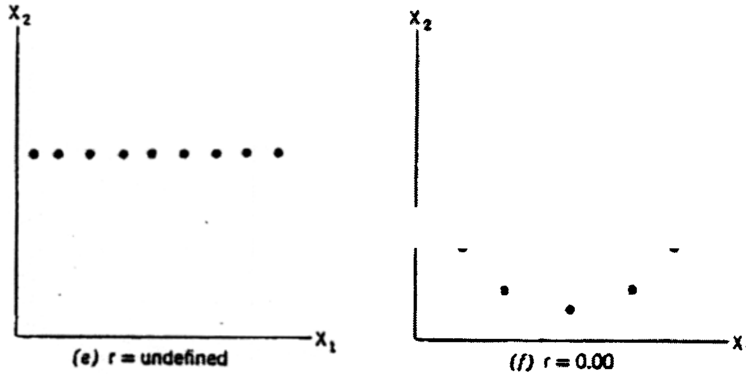
(3) zero correlation coefficient - no relationship

(4) range of .01 to 1.00 - direct relationship where the magnitude of the coefficient can be expressed as percent, where +1.00 = perfect direct relationship

(5) range of -.01 to -1.00 inverse relationship where the magnitude of the coefficient can be expressed as percent, where - 1.00 = perfect inverse relationship

(6) Some examples of correlation coefficients and the plot of the mutual variables are shown graphically below:





(e) r = undefined (f) r = 0.00

d. The correlation coefficient is an expression of the LINEAR relationship between two variables, therefore, the line of dependence between the variables must be linear.

e. The non-linear relationships, an algebraically equivalent and analagous correlation is calculated. This is the multiple correlation coefficient and this can be interpreted in the same fashion as the correlation coefficient; however, this is a corrected coefficient which is not subject to linear relationships only.

3. F - Test Ratios

The F-distribution is based on a probability distribution and tests the equality of variances by comparing:

a. The theoretical distribution of values that would be expected by randomly sampling from a normal population, and expressing the result as a cut-off (critical) value for a predetermined level of significance.

b. The ratio(s) of sample variances for all possible pairs, as shown below:

$$F = \frac{s_1^2}{s_2^2}$$

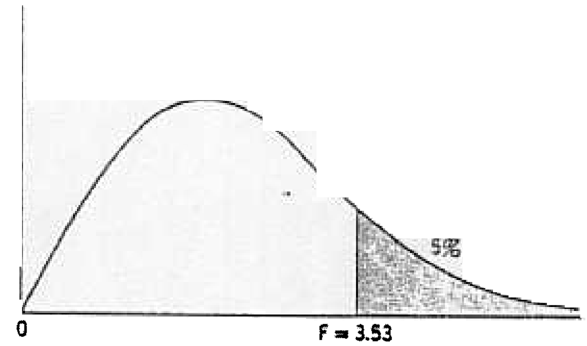
where s_1^2 is the larger variance and s_2^2 is the smaller. We now are testing the hypothesis

$$H_0: \sigma_1^2 = \sigma_2^2$$

against

$$H_1: \sigma_1^2 \neq \sigma_2^2$$

Stated simply, the F-test Treasures the ratio(s) of the sample variance and compares them to a standard Which would be expected if the samples came from the same population. Consider the graph below where a hypothetical F-distribution is given:



A typical F distribution with ν_1 = 10 and ν_2 = 25 degrees of freedom, with critical region (shown by shading) which contains 5% of the area under the curve. Critical value of F = 3.53.

a. If the sample ratios <u>exceeds</u> 3.53, the samples were not drawn from the sane normal population.

b. If the sample ratios <u>do not exceed</u> 3.53, then the samples are drawn from the same normal population.

c. Selection of Critical Values for F-tests

The shape of the F-distribution will change with changes in sample size. Since the F-distribution comperes a ratio of too sample variances to a probability distribution, an unbiased quantity called <u>degrees of freedom</u> is used to determine the critical value of F. The use of the degrees of - freedom <u>compensates</u> for the double use of observations by imposing a reduction of the total number.

<u>Degrees of Freedom</u> can be defined as the number of observations in a sample minus the number of parameters estimated from the sample. Restated, the degrees of freedom represents the number of independent comparisons that can be made between the observations in the estimating sample.

d. Selection of Level of Significance

The level of significance used in a F-distribution is expressed in %. This is a measure of the error associated with the comparison between the probability distribution and the F-test ratio. That is, if you were using a F-test to verify the appropriateness of a model and you wanted 95% accuracy, then the level of significance (acceptable error in the model) would be 0.05%. The level of significance in modeling often closely coincides to the standard deviation being utilized when describing the model variance, that is

F-test (.05 significance) - Standard Deviation - 2 (95%) F-test (.01 significance) - Standard Deviation - 3 (99%)

Methods of Comparing and Testing L' Dispersions for Multiple Populations

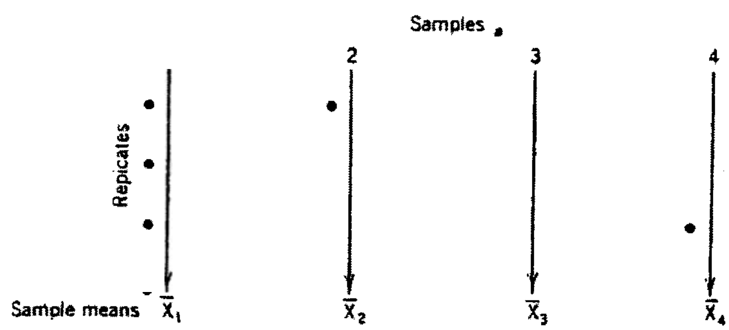
The carving and testing of the properties of dispersion of many well defined populations is generally approached by utilizing methods in the branch of statistics called analysis of variance. Generally, this involves the separation of the total variance of a group of measurements into the various components and sources. The tests of equality relate the simultaneous differences in means and in variances. Currently, two types of analysis of variance are widely used. They are:

1. One-Way Analysis of Variance

A one-way analysis of variance tests the:

a. Variance within each set of replicates b. Variance among the samples

The pattern of summation for one-way analysis of variance is given below:



Pattern of summation in analysis of variance.
(a) One-way analysis; summation proceeds down replicates to find sample means.

The standardized format for presentation of results of one-way analysis of variance is given below:

Source of variation	Sum of squares	Degrees of freedom	Mean squares	F test
Among samples	SS_A	$m-1$	MS_A	MS_A/MS_W
Within replications	SS_W	$N-m$	MS_W	
Total variation	SS_T	$N-1$		

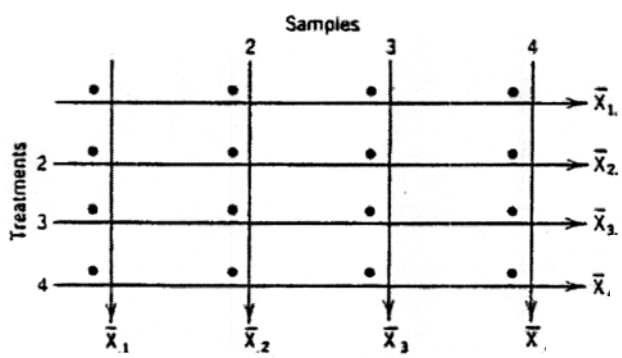
We will use a slightly modified version of the results format in the Examination of the linear regression program (which will be discussed in a later narrative).

2. Two-Way Analysis of Variance

A two-way analysis of variance tests the:

a. Variance among the treatments
b. b. variance among the samples

The pattern for summation of two-way analysis of variance is given below:



Pattern cf summation in analysis of variance.

(b) Two-way analysis, summation proceeds down treatments to find sample means and also across samples to find treatment means.

The standardized format for presentation of results of two-way analysis of variance is given below:

Source of variation	Sum of squares	Degrees of freedom	Mean squares	F tests
Among samples	SS_A	$m - 1$	MS_A	MS_A/MS_E [a]
Among treatments	SS_B	$n - 1$	MS_B	MS_B/MS_E [b]
Error	SS_E	$(m - 1)(n - 1)$	MS_E	
Total variation	SS_T	$N - 1$		

[a] Test of significance of differences between samples.
[b] Test of significance of differences between treatments.

We will utilize a slightly modified version of the results format for two-'gray analysis of variance in the analysis of the curvilinear regression program (which will be discussed in a later narrative).

Regression Analysis

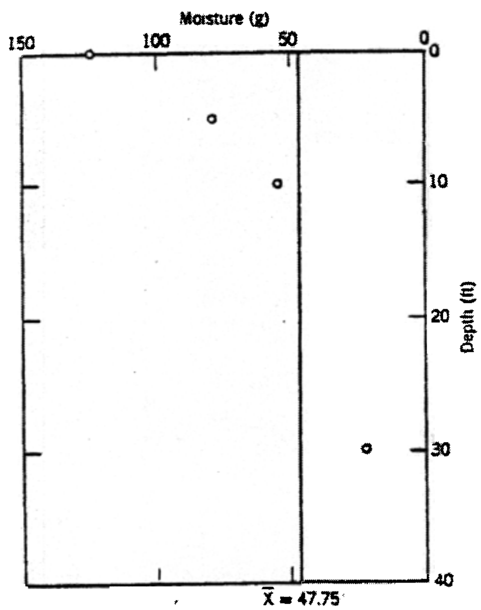
The regression analysis provides a method where the mean can be expressed as a function rather than a single value. This is accomplished by using simultaneous equations and minimizing the deviation of the predicted values from the actual values and by allowing the mean to have a slope which more closely matches the actual data. The regression mean permits the general tendency of the data to be analyzed and predicted. Since the mean is expressed as a function, appropriate values can be evaluated and mean line can be interpolated between data points; extrapolated beyond the sequence of data and estimate characteristics of the population.

The nature of the function is to minimize the deviations about the regression mean. Two of the most utilized regressions are

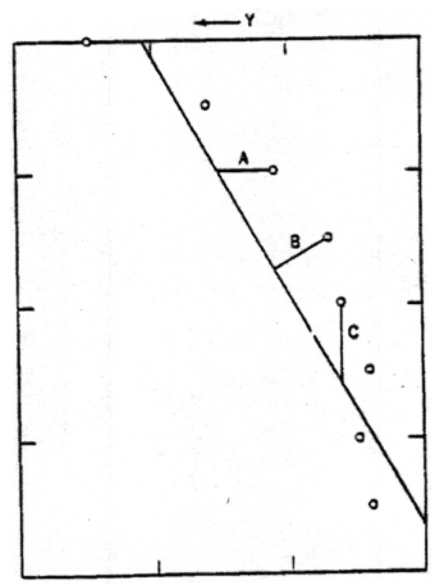
linear regression (line fitting)

2. curvilinear regression (curve fitting)

As the names imply, a linear regression expresses the mean as a function which graphs as a straight line. The advantage is that the mean line may have any slope. This advantage can be shown graphically below:



Plot of moisture content (grams water/100 grams dry weight) versus depth below sediment–water interface. Data collected from a core through Recent estuary mud in Louisiana bay. Note that orientation of plot corresponds to correct geologic orientation and not to standard mathematical form.



Possible criteria for minimization of deviations from fitted lines: A, minimization of deviations in moisture content; B, minimization of joint deviations; C, minimization of deviations in depth.

Note the increase in fit to the data for the sloped mean line (right).

However, when a function which graphs as a curved line is fitted to the same data, note the further increase in the appropriateness of the fit, as sown below

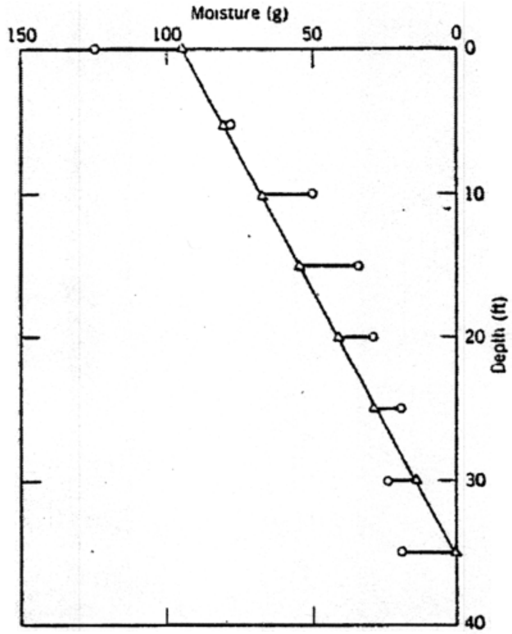


FIGURE 5.7. Observed values of moisture content and estimated values predicted by a straight line fitted by least squares.

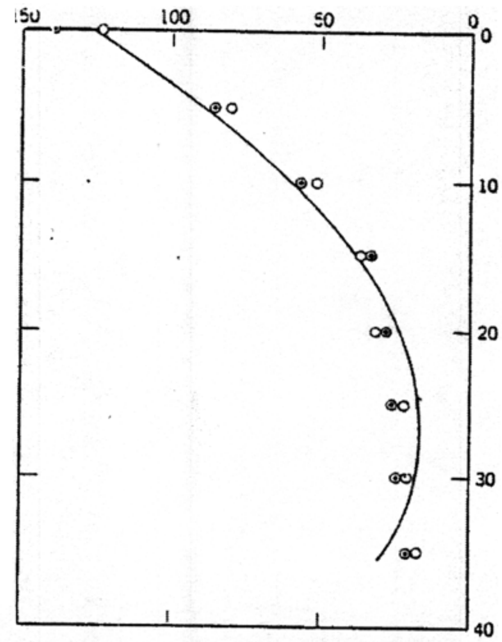


FIGURE 5.12. Second-degree polynomial regression fit to moisture data from Tables 5.7 and 5.10.

1. Testing Linear Regressions

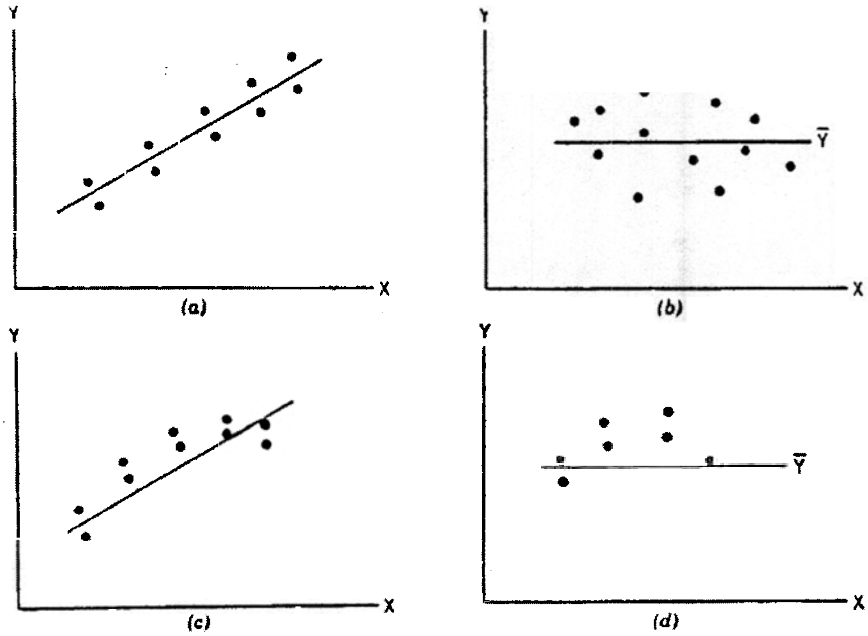
Linear regressions can be tested by analysis of variance procedures as previously described. The format for the analysis of variance is given below:

The Ftest ratio compares the variance about the regression line to the variance of, the population as estimated by the properties of the samples fan the population..

ANOVA for Simple Linear Regression

Source of variation	Sum of squares	Degrees of freedom	Mean squares	F test
Linear regression	SS_R	1	MS_R	MS_R/MS_D
	SS_D	$n-2$		
	SS_T	$n-1$		

Four possible relationships axis for straight line regressions when they are tested,as shown below:



Possible straight-line regression situations. (*a*) Significant linear regression, no lack of fit. (*b*) Linear regression not significant, no lack of fit. (*c*) Significant linear regression, significant lack of fit. (*d*) Linear regression not significant, significant lack of fit. (After Draper and Smith, 1966.)

F-test ratios will not exceed the critical value for graphs A and B; while Graphs C and D will have F-test ratios in the critical region as the regression is not significant.

We compensate for the "anomalous" fit at graph B by utilizing a quantity called the "goodness of fit," which is defined by the equation:

The goodness of fit is somewhat analogous to the covariance; as it is a ratio of the variance measures of the regression to the total population (as estimated from the samples.) The square root of the goodness of fit is a term called the multiple corre-lation coefficient as described below:

$$R = \sqrt{R^2} = \sqrt{SS_R/SS_T}$$

his definition is algebraically equivalent to the definition of the correlation

$$r = \frac{SS_{xy}}{\sqrt{SS_x \cdot SS_y}}$$

This equation is algebraically equivalent to the correlation coefficient, previously discussed.

2. Testing Curvilinear Regressions

The F-test and correlation coefficients will allow the reviewer to determine the suitability of a linear regression. The linear regression takes the form of a normal equation where:

$$Y_i = \beta_0 + \beta_1 X_i$$

If additional terms of B are to be estimated as a result of testing of the <u>linear</u> regression, then a polynomial expansion (which will graph as a curved line) will be required, as shown below

$$Y_i = b_0 + b_1 X_i + b_2 X_i^2 + b_3 X_i^3 + \quad + b_m X_i^m$$

The addition of each term of B (i. e. b_2X^2, b_3X^3) allows for increased flexibility to fit the data. However, a loss of degrees of freedom <u>decreases</u> the F-test critical value. This trade off means that while increased flexibility is gained, once the F-test value has been exceeded, no further significant estimation can be made.

Following completion of each curvilinear regression, the regression is tested and the results are displayed as shown below:

TABLE 5.12. ANOVA for Significance of Added Terms in Curvilinear Regression

Source of variation	Sum of squares	Degrees of freedom	Mean square	F test
Linear regression	SS_{R1}	1	MS_{R1}	
Quadratic regression	SS_{R2}	2	MS_{R2}	MS_{R2}/MS_{D2}[a]
Addition by quadratic	SS_{2-1}	1	MS_{2-1}	MS_{2-1}/MS_{D2}[b]
Quadratic deviation	SS_{D2}	$n-3$	MS_{D2}	
Total variation	SS_T	$n-1$		

[a]Tests for significance of the quadratic fit.
[b]Tests for significance of increase of quadratic over linear fit.

APPENDIX C

MISCELLANEOUS FORMS

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BGOU RI/FS
CELLULAR PHONE SIGN-OUT LOG

Cellular Phone No.	Date Out	Time Out	Initials	Time In	Initials

BGOU RI/FS
DOCUMENT CONTROL
DOCUMENT NAME

Controlled Copy No.	Person Assigned	Signature	Date Received	Date Returned	Signature

BGOU RI/FS
FIELD LOGBOOK SIGN-OUT LOG

Logbook name	Logbook No.	Date	Time out	Initials	Time In	Initials

BGOU RI/FS
RADIO SIGN-OUT LOG

Radio Model: ____________________

Radio Number: ____________________

Date Out	Time Out	Initials	Date and Time In	Initials

BGOU RI/FS
SIGN IN/SIGN OUT LOG SHEET

Name	Visitor badge no.	Affiliation	Work location	Type of work	Time		
					In	Estimated out	Out

BGOU RI/FS
INSPECTION OF METAL PLATE CLAMPS

Location	Date of Inspection	Manufacturer	Capacity
Item	Condition	Recommendations	

Held

_______ lbs for _______ minutes

INSPECTION OF LIFTING DEVICES

Location	Date of Inspection	Manufacturer	Capacity/Rating

Date of load test: _______________

Worn, cracked, or deformed/distorted parts such as lugs, eyes, welds, lifting attachments, etc.

____

Recommendations/Comments: _______________

Inspector

____
Iron worker and/or supervisor

Signature Signature Signature

BGOU RI/FS
MAINTENANCE AND CALIBRATION

Date: Time: AM/PM

Employee Name: Equipment Description:

Contract/Project: Equipment ID No.:

Activity: Equipment Serial No.:

MAINTENANCE

Maintenance Performed:

Comments:

Signature: Date:

CALIBRATION/FIELD CHECK

Calibration Standard: Concentration of Standard:

Lot Number of Calibration Standard: Expiration Date of Calibration Standard:

Pre-Calibration Reading: Post-Calibration Reading:

Pre-Field Check Reading: Post-Field Check Reading:

Adjustment(s):

Calibration: ☐ Passed ☐ Failed

Comments:

Signature: Date:

BGOU RI/FS
OVM FIELD CALIBRATION LOG

Project No. Supplier	Instrument Serial No. Telephone No.
Calibration Gas Calibration Gas Conc. (Span Setting) Response Factor ________ Alarm Setting	Calibration Gas Supplier Telephone No. Lamp Voltage

Date	Time	Operator	Lot No.	Battery Check	Machine Zeroed	Calibration Performed (Y/N)	Calibration Satisfactory (Y/N)	Calibration Check Value[a]	Comments

Calibration gas may be run through the OVM at the end of the day to check the stability of the instrument

BGOU RI/FS
SUBCONTRACTOR EQUIPMENT INSPECTION

Date

FPSC ________________ Title ________________

Subcontractor ________________

Construction Engineer ________________

Make ________________ Model ________________

License No. ________________ Serial ________________

Safety Inspection

	Yes	No	Comments
First aid kit			
Fire extinguisher			
Back-up alarm			
Lights			
Turn signals			
Seat belts			
Oil leaks			
Windshield wipers			
HYD Leaks			
Glass			
Mirrors			
Brakes			
Other			
QE inspection required			

____

Inspector

cc: Safety Department
Subcontractor
Data Center (RC) ESO#

BGOU RI/FS
TRAINING/MEETING RECORD

Topic: ______________________ Office Location:
Task Number: ______________________ Instructor: ______________________
Date: ______________________
Time: ______________________

Training/Meeting Content: ______________________

ATTENDANCE

Print name	Signature	Affiliation	Phone number

BGOU RI/FS
WELL DEVELOPMENT LOG

Well Development Log		Well no.:	Page of
Installation:		Site:	
Project No.:	Client/Project:		
Contractor:		Dev. Contractor:	
Dev. Start: (_____ M)	Dev. End (_______ M)		CSG DIA.:
Developed By:			Dev. Rig (Y/N)

Dev. Method ____

____

____

Equipment ____

____

Pre-dev. SWL

Maximum drawdown during pumping _________ ft at _______ gpm

Range and average discharge rate ______________________________________ gpm

Total quantity of material bailed ____________________________

Total quantity of water discharged by pumping ____________________

Disposition of discharged water __________

Time	Volume Removed (gals)	Water level ft. BTOC	Turbidity	Clarity /color	Temp °C	pH	Conductivity	Remarks

BGOU RI/FS
TEMPERATURE MONITORING PROGRAM

Cooler No. or Refrigerator No.	Thermometer Serial ID No.	Temperature Monitoring					
		Date	Time	Temp (°C)	Checked By (Name)	Within Req. Range (Y/N)	Corrective Action

Required Temperature Range: ______________________

APPENDIX D

DOCUMENT OUTLINES

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INTEGRATED RFI/RI REPORT

Executive Summary
1. Introduction
    - 1.1 Purpose of Report
    - 1.2 Site Background
        - 1.2.1 Site Description
        - 1.2.2 Site History
        - 1.2.3 Previous Investigations
    - 1.3 Report Organization
2. Study Area Investigation
    - 2.1 Includes all field activities associated with site characterization. These may include physical and chemical monitoring of some of the following:
        - 2.1.1 Surface Features
        - 2.1.2 Contaminant Source Investigations
        - 2.1.3 Meteorological Investigations
        - 2.1.4 Surface Water and Sediment Investigations
        - 2.1.5 Geological Investigations
        - 2.1.6 Soil and Vadose Zone Investigations
        - 2.1.7 Groundwater Investigations
        - 2.1.8 Human Population Surveys
        - 2.1.9 Ecological Investigations
    - 2.2 If technical memoranda documenting field activities were prepared, they may be included in an appendix and summarized in this report section.
3. Physical Characteristics of the Study Area
    - 3.1 Includes results of the field activities to determine physical characteristics. These may include some of the following:
        - 3.1.1 Surface Features
        - 3.1.2 Meteorology
        - 3.1.3 Surface Water Hydrology
        - 3.1.4 Geology
        - 3.1.5 Soils
        - 3.1.6 Hydrogeology
        - 3.1.7 Demography and Land Use
        - 3.1.8 Ecology
4. Nature and Extent of Contamination
    - 4.1 Presents the results of site characterization, both natural chemical components and contaminants of the following media:
        - 4.1.1 Sources (Lagoons, Sludges, Tanks, etc.)
        - 4.1.2 Soils and Vadose Zone
        - 4.1.3 Groundwater
        - 4.1.4 Surface Water and Sediments
        - 4.1.5 Air
5. Fate and Transport
    - 5.1 Potential Routes of Migration (i.e., Air, Groundwater, etc.)
    - 5.2 Contaminant Persistence
        - 5.2.1 Describe estimated persistence in the study area environment and physical, chemical, and/or biological factors of importance for the media of interest.

5.3 Contaminant Migration

5.3.1 Describe factors affecting contaminant migration for the media of importance (e.g., sorption onto soils, solubility in water, movement of groundwater, etc.).

5.3.2 Describe modeling methods and results, if applicable.

6. BRA

6.1 Human Health Evaluation

6.1.1 Exposure Assessment

6.1.2 Toxicity Assessment

6.1.3 Risk Characterization

6.2 Environmental Evaluation

7. Summary and Conclusions

7.1 Summary

7.1.1 Nature and Extent of Contamination

7.1.2 Fate and Transport

7.1.3 Risk Assessment

7.2 Conclusions

7.2.1 Data Limitations and Recommendations for Future Work

7.2.2 Recommended RA Objectives

Appendices

A Technical Memoranda on Field Activities

B Analytical Data and QA/QC Evaluation Results C Risk Assessment Methods

NOTE: Elements included in this outline shall be considered and incorporated, as appropriate, when developing the above-referenced document.

INTEGRATED FS/CMS REPORT

Executive Summary
1. Introduction
    1.1 Purpose and Organization of Report
    1.2 Background Information (Summarized from RI/RFI Report)
        1.2.1 Site Description
        1.2.2 Site History
        1.2.3 Nature and Extent of Contamination 1.2.4 Contaminant Fate and Transport 1.2.5 BRA
2. Identification and Screening of Technologies
    2.1 Introduction
    2.2 RA Objectives -
        Presents the development of RA objectives for each medium of interest. For each medium, the following should be discussed:
        2.2.1 Contaminants of Interest
        2.2.2 Allowable Exposure Based upon Risk Assessment (including ARARs)
        2.2.3 Development of Remediation Goals
    2.3 General Response Actions -
        For each medium of interest, describe the estimation of areas or volumes to which treatment, containment, or exposure technologies may be applied.
    2.4 Identification and Screening of Technology Types and Process Options - For each medium of interest, describe:
        2.4.1 Identification and Screening of Technologies
        2.4.2 Evaluation of Technologies and Selection of Representative Technologies
3. Development and Screening of Alternatives
    3.1 Development of Alternatives -
        Describes rationale for combination of technologies/media into alternatives.
    3.2 Screening of Alternatives (if conducted)
        3.2.1 Introduction
        3.2.2 Alternative 1
        3.2.2.1 Description
        3.2.2.2 Evaluation
        3.2.3 Alternative 2 (etc.)
        3.2.4 Alternative 3 (etc.)
4. Detailed Analysis of Alternatives
    4.1 Introduction
    4.2 Individual Analysis of Alternatives
        4.2.1 Alternative 1
            4.2.1.1 Description
            4.2.1.2 Assessment
        4.2.2 Alternative 2 (etc.)
        4.2.3 Alternative 3 (etc.)
    4.3 Comparative Analysis
Bibliography
    Appendices

NOTE: Elements included in this outline shall be considered and incorporated, as appropriate, when developing the above-referenced document.

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APPENDIX E

HISTORICAL DATA SUMMARY

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E.1. BGOU RISK COMPARISON DATA SUMMARY TABLES

Files included on this CD are titled:

BGOU OREIS Data (Microsoft Access®)
SWMU 2 Groundwater Risk Screening (Microsoft Excel®)
SWMU 2 Soil-Sediment Risk Screening (Microsoft Excel®)
SWMU 3 Groundwater Risk Screening (Microsoft Excel®)
SWMU 4 Groundwater Risk Screening (Microsoft Excel®)
SWMU 4 Soil-Sediment Risk Screening (Microsoft Excel®)
SWMU 5 Groundwater Risk Screening (Microsoft Excel®)
SWMU 5 Soil-Sediment Risk Screening (Microsoft Excel®)
SWMU 6 Groundwater Risk Screening (Microsoft Excel®)
SWMU 6 Soil-Sediment Risk Screening (Microsoft Excel®)
SWMU 7 and 30 Groundwater Risk Screening (Microsoft Excel®)
SWMU 7 and 30 Soil-Sediment Risk Screening (Microsoft Excel®)
SWMU 145 Groundwater Risk Screening (Microsoft Excel®)
SWMU 145 Soil-Sediment Risk Screening (Microsoft Excel®)
SWMU 145 Surface Water Risk Screening (Microsoft Excel®)
SWMU 7 and 30 Surface Water Risk Screening (Microsoft Excel®)
June-July 2004 Groundwater Data (Microsoft Access®)
Preliminary Remediation Goal Values (Microsoft Access®)

An explanation of the format of the files for the binning packages is provided below. Tables showing comparison values (such as Background Values and Industrial Worker Risk-Based Action Levels) are provided on the pages that follow.

E.1.1 FORMAT USED FOR BINNING PACKAGES PREPARED FOR SITE SCOPING

Binning packages are composed of a series of data summary and comparison tables and a user's guide. In the evaluation of potential risk and hazard, these are ordered as follows:

Table 1 – Analytes Never Detected in [MEDIUM]
Table 2 – Summary Statistics for Analytes Detected in [MEDIUM]
Table 3 – Comparison of Max. Detects to Risk-Based Action Levels
Table 4 – Comparison of Max. Detects to Risk-Based No Action Levels
Table 5 – Stations with Concentrations in [MEDIUM] Samples that Are Greater than Human Health Risk-Based Action Levels (Listed by Scenario and Sample Station)
Table 6 – Stations with Concentrations in [MEDIUM] Samples that Are Greater than the Human Health Risk-Based No Action Levels but Less than the Human Health Risk-Based Action Levels (Listed by Scenario and Sample Station)
User's Guide

In the evaluation of radiation dose, these are ordered as follows:

Table 1 – Analytes Never Detected in [MEDIUM]
Table 2 – Summary Statistics for Analytes Detected in [MEDIUM]
Table 3 – Comparison of Max. Detects to Dose-Based Action Levels
Table 4 – Comparison of Max. Detects to Dose-Based No Action Levels

Table 5 – Stations with Concentrations in [MEDIUM] Samples that Are Greater than Human Health Dose-Based Action Levels (Listed by Scenario and Sample Station)
Table 6 – Stations with Concentrations in [MEDIUM] Samples that Are Greater than the Human Health Dose-Based No Action Levels but Less than the Human Health Dose-Based Action Levels (Listed by Scenario and Sample Station)
User's Guide

The format for these tables (adapted from the User's Guide appearing in the binning package) is as follows:

Table E.1 Format for Tables in the Binning Packages

Table	Column Heading	Explanation
Table 1 – Analytes Never Detected	General Explanation	This table identifies compounds/analytes within the data set that have been analyzed but never detected. These compounds/analytes are not evaluated further in the following tables.
	Analysis Type	This column identifies the manner in which the data is sorted. Choices include inorganics, metals, volatiles, semivolatiles, other organics (PCBs and pesticides), and radionuclides.
	Analyte	This column contains the name of the compound/analyte.
	Units	This column identifies the units of the concentrations that are presented in subsequent columns for the analyte in this row.
	Number of Measurements	This value identifies the number of times the analyte was analyzed within the data set.
	Minimum SQL	This value represents the minimum sample quantitation limit (SQL) reported in the data set for the respective compound/analyte.
	Average SQL	This value represents the calculated average SQL using the SQLs reported in the data set for the respective compound/analyte.
	Maximum SQL	This value represents the maximum SQL reported in the data set for the respective compound/analyte.
Table 2 – Summary Statistics	General Explanation	This table identifies compounds/analytes within the data set that have been analyzed and detected. Summary statistics are calculated and presented to provide the decision-maker with a feel for the quality and extensiveness of the data set, and the detections are then compared to background values.
	Analysis Type	This column identifies the manner in which the data is sorted. Choices include inorganics, metals, volatiles, semivolatiles, other organics (PCBs and pesticides), and radionuclides.
	Analyte	This column contains the name of the compound/analyte.
	Units	This column identifies the units of the concentrations that are presented in subsequent columns for the analyte in this row.
	Proportion Detected	Presented as a ratio, the first value identifies the number of times the analyte was detected, and the second value identifies the total number of times the analyte was analyzed.
	Prop. "J" Det.	Presented as a ratio, the first value identifies the number of times the analytical results were flagged with a "J" qualifier indicating estimated values, and the second value identifies the total number of times the analyte was analyzed.
	Min Detect	This value represents the minimum single detected concentration of the analyte. The concentration is reported in the units (e.g., mg/kg, pCi/L) specified in the "Units" column.
	Arithmetic Mean	This value represents the calculated mathematical mean, or average, of the detected concentrations. The concentration is reported in the units (e.g., mg/kg, pCi/L) specified in the "Units" column.

Table E.1 Format for Tables in the Binning Packages (Continued)

Table	Column Heading	Explanation
Table 2 – (continued)	Std. Dev.	This value represents the calculated standard deviation of the detected concentrations. The concentration is reported in the units (e.g., mg/kg, pCi/L) specified in the "Units" column.
	Median Result	This value represents the median (i.e., midpoint between minimum and maximum detects) of the detected concentrations. The concentration is reported in the units (e.g., mg/kg, pCi/L) specified in the "Units" column.
	Freq. of MDL	Presented as a ratio, the first value identifies the number of times that the analyses in the database contain a method detection limit (MDL) value, and the second value identifies the total number of times the analyte was analyzed. (The OREIS database generally does not contain MDLs for data generated prior to circa 1993.)
	Min. MDL	This value represents the minimum MDL reported for all analyses. The concentration is reported in the units (e.g., mg/kg, pCi/L) specified in the "Units" column.
	Avg. MDL	This value represents the calculated average MDL reported for all analyses. The concentration is reported in the units (e.g., mg/kg, pCi/L) specified in the "Units" column.
	Max. MDL	This value represents the maximum MDL reported for all analyses. The concentration is reported in the units (e.g., mg/kg, pCi/L) specified in the "Units" column.
	Max. Detect	This value represents the maximum single detected concentration of the analyte. The concentration is reported in the units (e.g., mg/kg, pCi/L) specified in the "Units" column.
	FOD above 1X Bkgd.	Presented as a ratio, the first value identifies the number of times the detected analyte exceeded the background value, and the second value identifies the total number of times the analyte was analyzed.
	FOD above 2X Bkgd.	Presented as a ratio, the first value identifies the number of times the detected analyte exceeded the background value by a factor of 2, and the second value identifies the total number of times the analyte was analyzed. Note that the exceedences represented by the first number are also counted in the previous column (i.e., "FOD above 1X Bkgd").
	FOD above 10X Bkgd.	Presented as a ratio, the first value identifies the number of times the detected analyte exceeded the background value by a factor of 10, and the second value identifies the total number of times the analyte was analyzed. Note that the exceedences represented by the first number are also counted in the previous two columns (i.e., "FOD above lX Bkgd" and "FOD above 2X Bkgd").

Table E.1 Format for Tables in the Binning Packages (Continued)

Table	Column Heading	Explanation
Table 3 – Comparison of Max. Detects to Risk-Based Levels or Table 3 – Comparison of Max. Detects to Dose-Based Action Levels	General Explanation	These tables identify compounds/analytes within the data set that exceed screening values developed by the Core Team's Risk Workgroup specifically for the scoping/binning process. Each table represents a different risk range (i.e., >l0-4, l0-4 to 10-6). Each table or may contain multiple risk scenarios (e.g., industrial worker, child resident) that correspond with different land uses.
	Analysis Type	This column identifies the manner in which the data is sorted. Choices include inorganics, metals, volatiles, semivolatiles, other organics (PCBs and pesticides), and radionuclides.
	Analyte	This column contains the name of the compound/analyte.
	Units	This column identifies the units of the concentrations that are presented in subsequent columns for the analyte in this row.
	Max. Detect	This value represents the maximum single detected concentration of the analyte. The concentration is reported in the units (e.g., mg/kg, pCi/L) specified in the "Units" column.
	FOD above … Action	Presented as a ratio, the first value identifies the number of times that the detected analyte exceeded the risk-based screening value calculated for the given risk level (i.e., >10-4, l0-4 to 10-6) and exposure scenario (e.g., industrial worker, child resident), and the second value identifies the total number of times the analyte was analyzed.
Table 4 – Comparison of Max. Detects to Risk-Based No Action Levels Or Table 4 – Comparison of Max. Detects to Dose-Based No Action Levels	General Explanation	These tables identify specific samples within the data set that exceed screening values developed by the Core Team's Risk Workgroup for Levels the scoping/binning process. Each table represents a different risk range (i.e., >l0-4, 10-4 to 10-6). Each table contains multiple risk or scenarios (e.g., industrial worker, child resident) that correspond with different land uses. The data points that appear in these tables are graphically represented on the accompanying site maps.
	Area	This column clarifies the location of the data. (The information in this column may be considered redundant with the title of the data package.)
	Station	The stations signify the sample location.
	Depth	The column identifies the depth(s) from which the sample was collected.
	Chemical	The column identifies the chemical that exceeded the risk-based screening level.
	Frequency	This column identifies the number of times that the compound/analyte exceeded the respective screening lvel at a particular station. (For example, split and duplicate samples collected from the same station would cause this value to be greater than one.)

Table E.1 Format for Tables in the Binning Packages (Continued)

Table	Column Heading	Explanation
Table 5 – Stations with Concentrations in [MEDIUM] Samples that Are Greater than Human Health Risk-Based Action Levels (Listed by Scenario and Sample Station) or Table 5 – Stations with Concentrations in [MEDIUM] Samples that Are Greater than Human Health Dose-Based Action Levels (Listed by Scenario and Sample Station)	General Explanation	These tables list the stations that have a detected analyte concentration that exceeds the action screening levels. Within these tables, each detect is listed by station and analyte. Other information presented includes the depth of sampling, the number of detects at the station-depth combination exceeding the action level versus the total number of samples at that depth, the action level used for the analyte, and the units of measure.
Table 6 – Stations with Concentrations in [MEDIUM] Samples that Are Greater than the Human Health Risk-Based No Action Levels but Less than the Human Health Risk-Based Action Levels (Listed by Scenario and Sample Station) or Table 6 – Stations with Concentrations in [MEDIUM] Samples that Are Greater than the Human Health Dose-Based No Action Levels but Less than the Human Health Dose-Based Action Levels (Listed by Scenario and Sample Station)	General Explanation	These tables list the stations that have a detected analyte concentration that exceeds the no action screening levels, but are less than the action screening levels. Within these tables, each detect is listed by station and analyte. Other information presented includes the depth of sampling, the number of detects at the station-depth combination exceeding the action level versus the total number of samples at that depth, the action level used for the analyte, and the units of measure.

Table E.2 Groundwater Hazard Levels for Residential Land Use

Analytical Type	Chemical	Units	Adult Resident	Child Resident
Inorganics	Aluminum	mg/L	107.55	44.72
Inorganics	Ammonia	mg/L	1.39	0.29
Inorganics	Antimony (metallic)	mg/L	0.04	0.02
Inorganics	Arsenic, Inorganic	mg/L	0.03	0.01
Inorganics	Barium	mg/L	7.47	3.11
Inorganics	Beryllium and compounds	mg/L	0.19	0.08
Inorganics	Boron And Borates Only	mg/L	9.84	4.08
Inorganics	Cadmium (Water)	mg/L	0.05	0.02
Inorganics	Chloride	mg/L		
Inorganics	Cobalt	mg/L	6.56	2.72
Inorganics	Copper	mg/L	4.03	1.67
Inorganics	Cyanide (CN-)	mg/L	2.03	0.85
Inorganics	Iron	mg/L	32.46	13.48
Inorganics	Lead And Compounds	mg/L		
Inorganics	Lithium	mg/L	2.19	0.91
Inorganics	Magnesium	mg/L		
Inorganics	Manganese	mg/L	2.51	1.05
Inorganics	Mercury, Inorganic Salts	mg/L	0.03	0.01
Inorganics	Molybdenum	mg/L	0.54	0.23
Inorganics	Nickel Soluble Salts	mg/L	2.18	0.90
Inorganics	Nitrate	mg/L	174.57	72.37
Inorganics	Selenium	mg/L	0.55	0.23
Inorganics	Silver	mg/L	0.54	0.23
Inorganics	Sodium	mg/L		
Inorganics	Strontium, Stable	mg/L	65.11	27.02
Inorganics	Sulfate	mg/L		
Inorganics	Thallium (Soluble Salts)	mg/L		
Inorganics	Thorium	mg/L		
Inorganics	Tin	mg/L	64.53	26.83
Inorganics	Titanium	mg/L		
Inorganics	Uranium (Soluble Salts)	mg/L	0.07	0.03
Inorganics	Vanadium, Metallic	mg/L	0.65	0.28
Inorganics	White Phosphorus	mg/L	0.00	0.00
Inorganics	Zinc (Metallic)	mg/L	32.55	13.51
Inorganics	Zirconium	mg/L		
Organics	Acenaphthene	mg/L	1.39	0.41
Organics	Acetone	mg/L	3.37	0.82
Organics	Aroclor 1016	mg/L	0.00	0.00
Organics	Aroclor 1242	mg/L		
Organics	Aroclor 1248	mg/L		
Organics	Aroclor 1254	mg/L	0.00	0.00
Organics	Aroclor 1260	mg/L		
Organics	Benzene	mg/L	0.07	0.02
Organics	Benzoic Acid	mg/L	432.27	179.57
Organics	Bis(2-chloroethoxy)methane	mg/L		
Organics	Bis(2-ethylhexyl)phthalate	mg/L	1.80	0.77
Organics	Bromomethane	mg/L	0.05	0.01
Organics	Butyl Benzyl Phthlate	mg/L	18.08	7.77
Organics	Carbon Disulfide	mg/L	4.99	1.37
Organics	Carbon Tetrachloride	mg/L	0.02	0.01
Organics	Chlorobenzene	mg/L	0.56	0.14

Table E.2 Groundwater Hazard Levels for Residential Land Use (Continued)

Analytical Type	Chemical	Units	Adult Resident	Child Resident
Organics	Chloroform	mg/L	0.00	0.00
Organics	Chloromethane	mg/L	1.25	0.26
Organics	Chrysene	mg/L		
Organics	Cresol, m-	mg/L	5.19	2.17
Organics	Cresol, o-	mg/L	5.17	2.17
Organics	Cresol, p-	mg/L	0.52	0.22
Organics	Dibenzofuran	mg/L	0.14	0.03
Organics	Dibutyl Phthalate	mg/L	8.99	3.87
Organics	Dichlorobenzene, 1,2-	mg/L	2.10	0.50
Organics	Dichlorobenzene, 1,3-	mg/L	0.03	0.01
Organics	Dichlorobenzene, 1,4-	mg/L	0.97	0.24
Organics	Dichlorodifluoromethane	mg/L	2.44	0.54
Organics	Dichloroethane, 1,1-	mg/L	4.22	1.09
Organics	Dichloroethane, 1,2-	mg/L	0.07	0.01
Organics	Dichloroethylene, 1,1-	mg/L	0.30	0.07
Organics	Dichloroethylene, 1,2- (Mixed Isomers)	mg/L	0.30	0.07
Organics	Dichloroethylene, 1,2-cis-	mg/L	0.33	0.08
Organics	Dichloroethylene, 1,2-trans-	mg/L	0.67	0.16
Organics	Dichlorophenol, 2,4-	mg/L	0.29	0.12
Organics	Diethyl Phthalate	mg/L	86.76	36.01
Organics	Dimethylphenol, 2,4-	mg/L	1.57	0.69
Organics	Dimethylphthalate	mg/L	1091.48	452.48
Organics	Dioxane, 1,4-	mg/L		
Organics	Ethyl Chloride	mg/L	32.90	11.00
Organics	Ethylbenzene	mg/L	5.68	1.69
Organics	Fluoranthene	mg/L	1.41	0.68
Organics	Fluorene	mg/L	1.05	0.29
Organics	Hexanone, 2-	mg/L		
Organics	Isophorone	mg/L	21.56	8.96
Organics	Isopropanol	mg/L		
Organics	Methyl Ethyl Ketone	mg/L	11.50	2.60
Organics	Methyl Isobutyl Ketone	mg/L	0.99	0.22
Organics	Methylene Chloride	mg/L	5.63	2.06
Organics	Naphthalene	mg/L	0.04	0.01
Organics	Naphthalene, 2-Methyl	mg/L		
Organics	Octyl Phthalate, di-N-	mg/L	0.04	0.02
Organics	Phenanthrene	mg/L		
Organics	Phenol	mg/L	64.98	26.98
Organics	Polychlorinated Biphenyls (Total) (lowest risk)	mg/L		
Organics	Pyrene	mg/L	1.14	0.55
Organics	Tetrachloroethylene	mg/L	0.61	0.25
Organics	Toluene	mg/L	4.34	1.01
Organics	Trichloro-1,2,2-trifluoroethane, 1,1,2-	mg/L	369.00	81.10
Organics	Trichlorobenzene, 1,2,4-	mg/L	0.69	0.23
Organics	Trichloroethane, 1,1,1-	mg/L	2.93	1.01
Organics	Trichloroethane, 1,1,2-	mg/L	0.13	0.03
Organics	Trichloroethylene	mg/L	0.19	0.05
Organics	Trichlorofluoromethane	mg/L	7.28	1.73
Organics	Trimethylbenzene, 1,3,5-	mg/L	0.08	0.02
Organics	Vinyl Chloride	mg/L	0.26	0.09

Table E.2 Groundwater Hazard Levels for Residential Land Use (Continued)

Analytical Type	Chemical	Units	Adult Resident	Child Resident
Organics	Xylene, m-	mg/L	54.10	13.20
Organics	Xylene, Mixture	mg/L	9.22	1.96
Radionuclides	Am-241	pCi/L		
Radionuclides	Np-237+D	pCi/L		
Radionuclides	Pu-238	pCi/L		
Radionuclides	Pu-239	pCi/L		
Radionuclides	Ra-226+D	pCi/L		
Radionuclides	Rn-222+D	pCi/L		
Radionuclides	Sr-90+D	pCi/L		
Radionuclides	Tc-99	pCi/L		
Radionuclides	Th-230	pCi/L		
Radionuclides	U-234	pCi/L		
Radionuclides	U-235+D	pCi/L		

+D = plus daughters

Table E.3 Risk-Based Levels for Industrial Land Use and Background Levels for Soils

Analytical Type	Chemical	Units	NoAction Level	Action Level	Background Subsurface	Background Surface
Excavation Worker						
Inorganics	Antimony (metallic)	mg/kg	0.49	2205.76	0.21	0.21
Inorganics	Arsenic, Inorganic	mg/kg	0.32	2344.09	7.9	12
Inorganics	Beryllium and compounds	mg/kg	1.26	8421.06	0.69	0.67
Inorganics	Cadmium (Diet)	mg/kg	15.18	801.78	0.21	0.21
Inorganics	Copper	mg/kg	427.02	100000.00	25	19
Inorganics	Iron	mg/kg	2165.46	100000.00	28000	28000
Inorganics	Lead And Compounds	mg/kg	50.00	1250.00	23	36
Inorganics	Manganese	mg/kg	56.60	100000.00	820	1500
Inorganics	Mercury, Inorganic Salts	mg/kg	1.17	2123.55	0.13	0.2
Inorganics	Molybdenum	mg/kg	66.03	39002.41		
Inorganics	Nickel Soluble Salts	mg/kg	216.42	100000.00	22	21
Inorganics	Selenium	mg/kg	71.29	39125.29	0.7	0.8
Inorganics	Silver	mg/kg	41.24	38029.22	2.7	2.3
Inorganics	Uranium (Soluble Salts)	mg/kg	11.30	4740.00	4.6	4.9
Inorganics	Vanadium, Metallic	mg/kg	4.40	29480.77	37	38
Inorganics	Zinc (Metallic)	mg/kg	2664.47	100000.00	60	65
Organics	Acenaphthene	mg/kg	349.62	100000.00		
Organics	Acenaphthylene	mg/kg				
Organics	Anthracene	mg/kg	3342.07	100000.00		
Organics	Aroclor 1016	mg/kg	0.17	349.92		
Organics	Aroclor 1248	mg/kg	0.17	5830.00		
Organics	Aroclor 1254	mg/kg	0.17	99.98		
Organics	Aroclor 1260	mg/kg	0.17	5830.00		
Organics	Benz[a]anthracene	mg/kg	0.23	19800.00		
Organics	Benzo[a]pyrene	mg/kg	0.02	1980.00		
Organics	Benzo[b]fluoranthene	mg/kg	0.23	19800.00		
Organics	Benzo[k]fluoranthene	mg/kg	2.32	100000.00		
Organics	Carbon Tetrachloride	mg/kg	0.51	275.57		

Table E.3 Risk-Based Levels for Industrial Land Use and Background Levels for Soils (Continued)

Analytical Type	Chemical	Units	NoAction Level	Action Level	Background Subsurface	Background Surface
Excavation Worker, continued						
Organics	Chloroform	mg/kg	0.17	46.24		
Organics	Chrysene	mg/kg	23.20	100000.00		
Organics	Dibenz[a,h]anthracene	mg/kg	0.02	1980.00		
Organics	Dichloroethylene, 1,1-	mg/kg	0.12	2506.67		
Organics	Dichloroethylene, 1,2-cis-	mg/kg	17.10	5439.38		
Organics	Dichloroethylene, 1,2-trans-	mg/kg	28.44	8829.78		
Organics	Ethylbenzene	mg/kg	28.66			
Organics	Fluoranthene	mg/kg	241.95	100000.00		
Organics	Fluorene	mg/kg	337.88	100000.00		
Organics	Indeno[1,2,3-cd]pyrene	mg/kg	0.23	19800.00		
Organics	Naphthalene	mg/kg	30.43	9091.32		
Organics	Phenanthrene	mg/kg				
Organics	Polychlorinated Biphenyls (Total) (high risk)	mg/kg	0.17	5830.00		
Organics	Polychlorinated Biphenyls (Total) (lowest risk)	mg/kg	4.81	100000.00		
Organics	Polynuclear Aromatic Hydrocarbons (Total)	mg/kg	0.02	1980.00		
Organics	Pyrene	mg/kg	181.46	100000.00		
Organics	Trichloroethylene	mg/kg	3.25	3487.71		
Organics	Vinyl Chloride	mg/kg	0.14	4730.00		
Organics	Xylene, o-	mg/kg	5587.55	100000.00		
Radionuclides	Am-241	pCi/g	1.74	40200.00		
Radionuclides	Cs-137+D	pCi/g	0.12	2650.00	0.28	0.49
Radionuclides	Np-237+D	pCi/g	0.33	7580.00		0.1
Radionuclides	Pu-239	pCi/g	1.63	37700.00		0.025
Radionuclides	Ra-226+D	pCi/g	0.03	763.00	1.5	1.5
Radionuclides	Sr-90+D	pCi/g	2.59	59900.00		4.7
Radionuclides	Tc-99	pCi/g	57.90	1340000.00	2.8	2.5

Table E.3 Risk-Based Levels for Industrial Land Use and Background Levels for Soils (Continued)

Analytical Type	Chemical	Units	NoAction Level	Action Level	Background Subsurface	Background Surface
Excavation Worker, continued						
Radionuclides	Th-228+D	pCi/g	0.04	825.00	1.6	1.6
Radionuclides	Th-230	pCi/g	2.22	51200.00	1.4	1.5
Radionuclides	U-234	pCi/g	2.84	65800.00	2.4	2.5
Radionuclides	U-235+D	pCi/g	0.46	10500.00	0.14	0.14
Industrial Worker						
Inorganics	Antimony (metallic)	mg/kg	0.38	462.79	0.21	0.21
Inorganics	Arsenic, Inorganic	mg/kg	0.52	315.00	7.9	12
Inorganics	Beryllium and compounds	mg/kg	0.95	1276.92	0.69	0.67
Inorganics	Cadmium (Diet)	mg/kg	21.29	70.48	0.21	0.21
Inorganics	Copper	mg/kg	493.23	100000.00	25	19
Inorganics	Iron	mg/kg	2066.97	100000.00	28000	28000
Inorganics	Lead And Compounds	mg/kg	50.00	1250.00	23	36
Inorganics	Manganese	mg/kg	45.20	46400.00	820	1500
Inorganics	Mercury, Inorganic Salts	mg/kg	0.98	825.46	0.13	0.2
Inorganics	Molybdenum	mg/kg	82.98	25001.72		
Inorganics	Nickel Soluble Salts	mg/kg	241.52	93013.48	22	21
Inorganics	Selenium	mg/kg	94.87	25647.15	0.7	0.8
Inorganics	Silver	mg/kg	41.06	20747.37	2.7	2.3
Inorganics	Uranium (Soluble Salts)	mg/kg	20.20	3340.00	4.6	4.9
Inorganics	Vanadium, Metallic	mg/kg	3.32	4471.25	37	38
Inorganics	Zinc (Metallic)	mg/kg	2725.33	100000.00	60	65
Organics	Acenaphthene	mg/kg	316.06	66741.78		
Organics	Acenaphthylene	mg/kg				
Organics	Anthracene	mg/kg	3786.48	100000.00		
Organics	Aroclor 1016	mg/kg	0.20	42.50		
Organics	Aroclor 1248	mg/kg	0.20	42.50		
Organics	Aroclor 1254	mg/kg	0.20	18.21		
Organics	Aroclor 1260	mg/kg	0.20	42.50		
Organics	Benz[a]anthracene	mg/kg	0.21	208.00		

Table E.3 Risk-Based Levels for Industrial Land Use and Background Levels for Soils (Continued)

Analytical Type	Chemical	Units	NoAction Level	Action Level	Background Subsurface	Background Surface
Industrial Worker, continued						
Organics	Benzo[a]pyrene	mg/kg	0.02	20.80		
Organics	Benzo[b]fluoranthene	mg/kg	0.21	208.00		
Organics	Benzo[k]fluoranthene	mg/kg	2.12	2080.00		
Organics	Carbon Tetrachloride	mg/kg	0.41	23.06		
Organics	Chloroform	mg/kg	0.12	3.70		
Organics	Chrysene	mg/kg	21.20	20800.00		
Organics	Dibenz[a,h]anthracene	mg/kg	0.02	20.80		
Organics	Dichloroethylene, 1,1-	mg/kg	0.10	12.10		
Organics	Dichloroethylene, 1,2-cis-	mg/kg	13.36	463.43		
Organics	Dichloroethylene, 1,2-trans-	mg/kg	22.02	743.20		
Organics	Ethylbenzene	mg/kg	21.21	2120.79		
Organics	Fluoranthene	mg/kg	220.59	64988.50		
Organics	Fluorene	mg/kg	339.25	70890.80		
Organics	Indeno[1,2,3-cd]pyrene	mg/kg	0.21	208.00		
Organics	Naphthalene	mg/kg	23.64	766.39		
Organics	Phenanthrene	mg/kg				
Organics	Polychlorinated Biphenyls (Total) (high risk)	mg/kg	0.20	42.50		
Organics	Polychlorinated Biphenyls (Total) (lowest risk)	mg/kg	5.69	1210.00		
Organics	Polynuclear Aromatic Hydrocarbons (Total)	mg/kg	0.02	20.80		
Organics	Pyrene	mg/kg	165.44	48741.38		
Organics	Trichloroethylene	mg/kg	2.51	298.48		
Organics	Vinyl Chloride	mg/kg	0.13	41.40		
Organics	Xylene, o-	mg/kg	4528.71	100000.00		
Radionuclides	Am-241	pCi/g	5.16	516.00		
Radionuclides	Cs-137+D	pCi/g	0.09	8.58	0.28	0.49
Radionuclides	Np-237+D	pCi/g	0.27	27.10		0.1

Table E.3 Risk-Based Levels for Industrial Land Use and Background Levels for Soils (Continued)

Analytical Type	Chemical	Units	NoAction Level	Action Level	Background Subsurface	Background Surface
Industrial Worker, continued						
Radionuclides	Pu-239	pCi/g	11.50	1150.00		0.025
Radionuclides	Ra-226+D	pCi/g	0.03	2.56	1.5	1.5
Radionuclides	Sr-90+D	pCi/g	7.44	744.00		4.7
Radionuclides	Tc-99	pCi/g	362.00	36200.00	2.8	2.5
Radionuclides	Th-228+D	pCi/g	0.03	2.80	1.6	1.6
Radionuclides	Th-230	pCi/g	14.90	1490.00	1.4	1.5
Radionuclides	U-234	pCi/g	19.80	1980.00	2.4	2.5
Radionuclides	U-235+D	pCi/g	0.40	39.50	0.14	0.14

+D = plus daughters

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APPENDIX F

HISTORICAL RISK ASSESSMENT SUMMARY

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ACRONYMS

ABS	dermal absorption factors
ARAR	applicable or relevant and appropriate requirement
AT123D	Analytical, Transient One-, Two-, and Three-Dimensional Model
BERA	baseline ecological risk assessment
bgs	below ground surface
BHHRA	baseline human health risk assessment
bls	below land surface
CDI	chronic daily intake
COC	chemical of concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
DOE	U.S. Department of Energy
ED	exposure duration
EF	exposure frequency
ELCR	Excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
FS	feasibility study
GWOU	groundwater operable unit
HI	hazard index
HQ	hazard quotient
HU	hydrogeologic unit
IEUBK	Integrated Exposure Uptake Biokinetic
KDEP	Kentucky Department for Environmental Protection
KPDES	Kentucky Pollutant Discharge Elimination System
LOAEL	lowest observed adverse effect levels
LUCAP	Land Use Control Assurance Plan
MCL	maximum contaminant level
MEPAS	Multimedia Environmental Pollutant Assessment System
mrem	millirem
MUSLE	Modified Universal Soil Loss Equation
NOAEL	no observed adverse effect level
OCDD	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin
OU	Operable Unit
PAHs	polyaromatic hydrocarbons
PCBs	polychlorinated biphenyls
PGDP	Paducah Gaseous Diffusion Plant
POC	pathways of concern
RAGS	Risk Assessment Guidance for Superfund
RAO	remedial action objective
RBC	risk-based concentrations
RCRA	Resource Conservation and Recovery Act
RDA	recommended daily allowance
RfD	reference dose
RGA	Regional Gravel Aquifer
RME	reasonable maximum exposure
RI	remedial investigation
SERA	screening ecological risk assessment

SMP	Site Management Plan
SWMU	solid waste management unit
SWOU	Surface Water Operable Unit
Tc	technetium
TCE	trichloroethene
U	uranium
UCRS	upper continental recharge system
VOC	volatile organic compound
WAG	Waste Area Grouping
WKWMA	West Kentucky Wildlife Management Area
yr	year

F.1. WASTE AREA GROUPING (WAG) 3 SUMMARY

The following is a summary of the baseline risk assessment found in the *Remedial Investigation Report for Waste Area Grouping 3 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1895/V1-V4&D1, U.S. Department of Energy, Paducah, KY.

This baseline risk assessment utilizes information collected during the recently completed RI of WAG 3 and the results of previous risk assessments for SWMUs in WAG 3 to characterize the baseline risks posed to human health and the environment from contact with contaminants in soil and groundwater. In addition, the baseline risk assessment uses results of fate and transport modeling to estimate the baseline risks posed to human health through contact with receiving media impacted by contaminants migrating off-site from the various sources in WAG 3. The ecological assessment focuses on exposure to contaminants in surface soil. Evaluation of off-site streams is deferred to the surface water OU investigation. Baseline risks are those that may be present now or in the future in the absence of corrective or remedial actions. Methods used for fate and transport modeling are presented in Chap. 5 of the RI report Vol. 1, Appendix B of Vol. 4 (MEPAS), and Appendix C (RESRAD) of Vol. 4.

To facilitate data aggregation and to focus results on specific areas, this baseline risk assessment derives hazard and risk estimates for the following SWMUs:

- SWMU 4—C-747 Contaminated Burial Yard
- SWMU 5—C-746-F Classified Burial Yard
- SWMU 6—C-747-B Burial Ground

Consistent with regulatory guidance and agreements contained in the approved human health risk assessment methods document, the BHHRA evaluates land use scenarios that encompass current use and several hypothetical future uses of the WAG 3 SWMUs and the areas to which contaminants may migrate. The following land use scenarios and exposure routes are assessed:

Current industrial worker

- Incidental ingestion of soil
- Dermal contact with soil
- Inhalation of vapors and particulates emitted from soil
- External exposure to ionizing radiation emitted from soil

Future industrial worker

- Incidental ingestion of soil
- Dermal contact with soil
- Inhalation of vapors and particulates emitted from soil
- External exposure to ionizing radiation emitted from soil
- Ingestion of groundwater
- Dermal contact with groundwater while showering

This appendix contains summaries of risk assessments for historical perspective only. These assessments were prepared with information available at the time. Additional information may have become available since their development; therefore, results and conclusions presented within this appendix should be considered information only.

- Inhalation of vapors emitted by groundwater while showering

Future excavation worker

- Incidental ingestion of soil (soil and waste)
- Dermal contact with soil (soil and waste)
- Inhalation of vapors and particulates emitted from soil (soil and waste)
- External exposure to ionizing radiation emitted from soil (soil and waste)

Future recreational user

- Ingestion of venison grazing on vegetation grown in contaminated soil
- Ingestion of rabbit grazing on vegetation grown in contaminated soil
- Ingestion of quail grazing on vegetation grown in contaminated soil

Future on-site rural resident

- Incidental ingestion of soil
- Dermal contact with soil
- Inhalation of vapors and particulates emitted from soil
- External exposure to ionizing radiation emitted from soil
- Ingestion of groundwater
- Dermal contact with groundwater while showering
- Inhalation of vapors emitted by groundwater during household use
- Inhalation of vapors emitted by groundwater while showering
- Ingestion of vegetables grown in contaminated soil

Off-site rural resident (at PGDP security fence)

- Ingestion of groundwater
- Dermal contact with groundwater while showering
- Inhalation of vapors emitted by groundwater during household use
- Inhalation of vapors emitted by groundwater while showering

Also consistent with regulatory guidance and the strategy for ecological risk assessment of source units , the baseline ecological risk assessment (BERA) evaluates risks under both current and potential future conditions to several ecological receptors that may come into contact with contaminated media at or migrating from sources in WAG 3. The land uses and media assessed for risks to human health and ecological receptors for each SWMU in WAG 3 are presented in Table F.1.1.

Major conclusions and observations of the BHHRA and BERA are presented in the following sections.

F.1.1 BHHRA—PRINCIPAL FINDINGS

For all SWMUs in WAG 3, the cumulative human health systemic toxicity and ELCR exceed the accepted standards of KDEP and EPA for one or more land use scenarios when assessed using default exposure parameters. The land use scenarios for which risks exceed *de minimis* levels [i.e., for KDEP, a

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cumulative hazard index (HI) of 1 or a cumulative ELCR of 1.0E-06, and for EPA, an HI of 1 and a range of 1.0E-04–1.0E-06 for ELCR] are summarized in Table F.1.2. This information is derived from the risk summary tables (Tables F.1.3–F.1.5), which present the cumulative risk values for each land use scenario, the COCs, and the pathways of concern (POCs).

F.1.1.1 Lead

A striking feature of the results of the BHHRA are the exceedingly high HIs that have been computed for land use scenarios, SWMUs, and media in which lead was detected (HIs of up to 2,390,000). This finding may be attributed to the use of a very conservative (1.0E-07 mg/kg-day) reference dose (RfD) value provided by KDEP. Where lead was detected, it was the overwhelming risk driver. To accommodate any uncertainty associated with this finding, the systemic toxicity associated with contaminants at WAG 3 has been assessed throughout this BHHRA by both including and excluding lead as a COPC. This strategy allows the identification of other contaminants contributing to significant levels of systemic toxicity and highlights HIs that exceed the *de minimus* level (i.e., HI > 1) in the absence of lead.

In an effort to reduce the uncertainty surrounding assessment of systemic toxicity at WAG 3 SWMUs where lead is present, two further analytical approaches are included in this risk assessment. Risks to exposed children were estimated using EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model, and the reasonable maximum exposure (RME) concentrations of lead in soil and groundwater samples were compared to KDEP and EPA screening values.

Applying the biokinetic model for lead indicates that the concentrations in RGA groundwater at SWMUs 4, 5 and 6 (159, 195, and 227 :g/L, respectively) and McNairy groundwater at the same locations (2150, 708, and 698 :g/L, respectively) result in unacceptable blood level concentrations in a child (66.92, 75.59, and 81.13 percent probability, respectively, for RGA groundwater at SWMUs 4, 5, and 6 and 99.97, 98.67, and 98.67 percent probability, respectively, for McNairy groundwater at the same locations). These findings are consistent with the respective lead-driven HIs of 71,100, 218,000, and 253,000, respectively, at SWMUs 4, 5, and 6 applicable to a future child rural resident exposed to RGA groundwater and HIs of 2,390,000, 789,000, and 778,000, respectively, for the child exposed to McNairy groundwater.

The RME lead concentrations in RGA and McNairy groundwater at the subject locations are also greater than the KDEP and EPA screening level concentrations for this element (4 and 15 :g/L, respectively). Therefore, when these findings are considered together, there is qualitative agreement on the potential hazards of prevailing lead concentrations in the groundwater at these SWMUs.

Where lead was detected in subsurface soil, lead-driven HIs of greater than 1000 for the future excavator contrast markedly with very low probabilities (<0.02%) of children having blood lead levels greater than 10 :g/dL, as determined by the IEUBK model. Furthermore, lead concentrations in subsurface soil at SWMUs 4 and 6 do not exceed the soil screening values specified by either agency. These findings point to a dichotomy between the findings of the IEUBK model for the metal in soil and the determinations of lead-driven systemic toxicity as indicated by the pathway-specific HIs.

Because the risks calculated using the provisional lead RfD are so uncertain, all observations presented in Tables F.1.3–F.1.5 exclude the quantitative contribution from lead.

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F.1.1.2 Exposure Routes

Dermal contact with soil has been a driving exposure pathway in previous BHHRAs at PGDP, with most of this risk arising from contact with metals. This is a direct result of using dermal absorption factors (ABS values) that exceed gastrointestinal absorption values and may be overly conservative. In such circumstances, risk estimates from the dermal exposure route may be unrealistic and exceed the real risk posed by this route of exposure. Although chemical-specific ABS values were used when available, default ABS values were used for most chemicals because chemical-specific values are lacking. Chemical-specific ABS values are available for PCBs and cadmium and were used in this BHHRA. Remedial decisions based on the dermal contact with soil exposure route should be carefully considered because of the uncertainty associated with risk from this exposure route.

While the dermal pathway may represent an important route of contaminant uptake for persons exposed to soil at WAG 3, ingestion of groundwater appears to represent the most important mechanism of uptake of contaminants from the RGA aquifer and McNairy Formation, with ingestion of groundwater-irrigated vegetables also representing a significant pathway for the hypothetical on-site resident.

F.1.1.3 Land Use Scenario Hazards/Risks/COCs

F.1.1.3.1 Current and future industrial worker

Soil hazards (total HIs) for the current industrial worker exceed *de minimis* levels (HI >1 or ELCR >1.0E-06) at only one SWMU, SWMU 4 (HI = 3.62). The contaminants at SWMU 4 contributing more than 10% to total HI are chromium, iron, and vanadium, with dermal contact as the driving exposure route. Soil cancer risks (total ELCRs) for the current industrial worker exceed *de minimis* levels at SWMUs 4, 5, and 6 (ELCRs > 1.0E-04). The major contaminant in surface soils at all SWMUs is beryllium, with significant contributions from PAHs at SWMUs 5 and 6. For all SWMUs, dermal contact is the driving exposure route.

The future industrial land use scenario is identical to the current industrial land use scenario except that the future industrial land use scenario also evaluates use of groundwater. Groundwater HIs for the future industrial worker exceed *de minimis* levels at all SWMUs (16,000–216,000); however, these hazards are markedly reduced by excluding lead as a COPC (19.1–75.9). Iron, manganese, vanadium, and trichloroethene contribute more than 10% to total HIs, with ingestion as the driving exposure route. Iron is both widespread and predominant as a COC, contributing 61–80% to HI, depending on location. Groundwater ELCRs for the future industrial worker exceed *de minimis* levels at all SWMUs (>1.0E-04). Arsenic, beryllium, trichloroethene, and radium-226 contribute more than 10% to ELCR, with ingestion as the driving exposure route.

F.1.1.3.2 Future excavation worker

Total soil and waste HIs for the future excavation worker exceed *de minimis* levels at all SWMUs (2.16–1750) but fall below 3 when lead is excluded as a COPC. Chromium, iron, manganese, and vanadium are the contaminants contributing more than 10% to HI, with dermal contact as the driving exposure route. Total soil and waste ELCRs for the future excavator exceed *de minimis* levels at all SWMUs (> 1.0E-04). Total uranium is the major contributor to ELCR at SWMU 4 (83%), with external exposure as the driving exposure route. Beryllium and total PAHs contribute 10% or more to ELCR at SWMU 5, with dermal contact as the driving exposure route. Beryllium is the major contributor to ELCR at SWMU 6, with dermal contact as the driving exposure route.

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F.1.1.3.3 Future rural resident

Soil HIs for the future rural resident exceed *de minimis* levels at all SWMUs but are less than 100 when lead is excluded as a COPC. Aluminum, arsenic, chromium, iron, and nickel contribute more than 10% to total HIs, with dermal contact with soil and ingestion of vegetables raised in soil as the driving exposure routes. The uncertainty associated with the dermal pathway has been previously discussed. Exclusion of the vegetable pathway would reduce soil HIs for the rural resident by as much as 87%. Soil ELCRs for the future rural resident exceed *de minimis* levels at all SWMUs (> 1.0E-03). Beryllium and uranium-238 contribute 10% or more to ELCR at SWMU 4, with ingestion of vegetables as the driving exposure route. Arsenic and total PAHs contribute 10% or more to ELCR, with ingestion of vegetables as the driving exposure route. Beryllium and total PAHs contribute 10% or more to ELCR at SWMU 6, with ingestion of vegetables as the driving exposure route. Exclusion of the vegetable pathway would reduce soil ELCRs for the rural resident by as much as 90%.

Groundwater HIs for the future rural resident exceed *de minimis* levels at all SWMUs (218,000–2,390,000) but are reduced by several orders of magnitude with lead excluded as a COPC (223–798). Iron, manganese, vanadium, carbon tetrachloride, and trichloroethene contribute more than 10% to total HI, with ingestion of water and ingestion of vegetables irrigated with water as the driving exposure routes. As for the future industrial worker land use scenario, iron is both widespread and predominant as a COC, contributing 49–77% to HI, depending on location. Exclusion of the vegetable pathway would reduce groundwater HIs for the rural resident by as much as 40%. Groundwater ELCRs for the future rural resident exceed *de minimis* levels at all SWMUs (> 1.0E-03). Arsenic, beryllium, 1,1-dichloroethane, trichloroethane, radium-226, and technetium-99 contribute more than 10% to ELCR, with ingestion of water and ingestion of vegetables irrigated with water as the driving exposure pathways. Exclusion of the vegetable pathway would reduce groundwater ELCRs for the rural resident by as much as 46%.

F.1.1.3.4 Future recreational user

The future recreational user scenario is not of concern regarding total soil HI at any WAG 3 SWMU. In terms of cancer risks, total soil ELCR exceeds *de minimis* levels only at SWMU 5 (1.0E-05), where PAHs contribute 96% to risk, with ingestion of rabbit as the driving exposure route.

F.1.1.3.5 Modeled On-site and Off-site COCs

As noted previously, this baseline risk assessment uses results of fate and transport modeling (MEPAS) to estimate the baseline risks posed to human health through contact with media impacted by contaminants migrating off-site from the various sources in WAG 3. The following chemicals are “priority COCs” for MEPAS-modeled off-site use of groundwater (i.e., rural residential use in the home). The following chemicals are COCs that may migrate from a source at a SWMU in WAG 3 to an off-site location and present a chemical-specific HI or ELCR to the rural resident that is greater than 0.1 or 1.0E-06, respectively:

- SWMU 4—arsenic, cobalt, copper, iron, manganese, nickel, vanadium, 1,1-dichloroethene, 1,2-dichloroethene, carbon tetrachloride, trichloroethene, vinyl chloride, neptunium-237, plutonium-239, technetium-99, total uranium (assessed as uranium-238), and uranium-238

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- SWMU 5—iron and manganese

- SWMU 6—iron and manganese

The RESRAD model was used to model both dose and excess cancer risk for radionuclides, accounting for in-growth of decay products. The following chemicals are "priority COCs" for modeled on-site soil use (i.e., industrial and excavator) and on-site groundwater use (i.e., rural residential use in the home). These chemicals are radionuclides that, through in-growth of decay products, present a chemical-specific ELCR that exceeds 1.0E-06 from exposure to surface and subsurface soil and waste at SWMUs in WAG 3 and radionuclides that may migrate from a source at a SWMU in WAG 3 to on-site RGA groundwater and present a chemical-specific ELCR to the rural resident that is greater than 1.0E-06:

- SWMU 4—thorium-230, total uranium (modeled as uranium-238), and uranium-238

- SWMU 5—radium-226 and uranium-238

- SWMU 6—neptunium-237, technetium-99, and uranium-238

F.1.1.4 Further Observations

The effects of the use of the conservative provisional RfD for lead and conservative ABS values have been noted. In addition, the following observations should be examined when considering remedial alternatives for WAG 3 SWMUs.

- As discussed in *Background Levels of Selected Radionuclides and Metals in Soils and Geologic Media at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1997), several metals and radionuclides exist in surface and subsurface soils at WAG 3 SWMUs at background concentrations that are higher than their industrial and residential risk-based concentrations (RBCs). These metals and radionuclides are aluminum, arsenic, beryllium, iron, lead, manganese, vanadium, and radium-226.

- A particular case in point is iron. A substantial portion of the total systemic toxicity associated with both soil and groundwater for several land use scenarios at WAG 3 is due to iron. Similar to lead, iron has a provisional RfD that is very conservative. Unlike lead, iron is an essential human nutrient. The RDA for iron is 10 mg/day, below which a person could be expected to be deficient.

  To be retained as a COPC for quantitative evaluation in the BHHRA, certain threshold concentrations must be exceeded, thus the maximum detected concentration of an analyte (per medium) is compared to various screening values (e.g., background concentration, RBC, and one-fifth the RDA). For example, the maximum detected concentration of iron in SWMU 4 surface soil is 30,700 mg/kg. This concentration is just slightly above the background level of 28,000 mg/kg, yet the residential use RBC for iron in surface soil (calculated using the conservative RfD) is 310 mg/kg, three orders of magnitude lower than background. The maximum detected concentration of iron in SWMU 4 surface soil yields a child intake of 6.14 mg/day, which exceeds one-fifth the RDA (2.0 mg/day) used as a screening value. Having exceeded all these screening values, iron was retained as a COPC. Using the actual representative concentration (95% upper confidence limit of the mean) of iron in SWMU 4 surface soil (17,800 mg/kg) yields a child daily intake of 3.56 mg/day, clearly less than the RDA, yet because of the conservative RfD, this dose results in a hazard quotient of 59 for iron alone, which contributes 60% to the total site HI (98).

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- The identification of total PAHs as risk drivers in soil at some SWMUs in WAG 3 agrees with previous risk assessments; however, the significance of this finding should be considered along with the sources previously and currently identified at PGDP. Generally, before taking action to address PAH contamination in soil at WAG 3 SWMUs, it may be prudent to consider the widespread nature of PAH contamination at PGDP, the continuing sources of contamination (e.g., motorized vehicles, asphalt paving, etc.), and the level of PAH contamination at areas outside PGDP.

- Subsurface soil and waste were treated as one medium in this BHHRA for excavator exposures; however, waste cells were sampled in SWMUs 4 and 6. The hazards and risks associated with subsurface samples that were collected from the waste cells, and thereby considered to be composed primarily of waste, were compared to subsurface soil samples collected from the periphery of the pits and thereby considered to consist largely of soil. Hazards and risks associated with the putative waste material in SWMUs 4 and 6 were considerably lower than those of the surrounding areas of soil and waste combined (default condition). For example, the ELCR for a future excavation worker exposed to soil at SWMU 4 was greater than that of an excavation worker exposed to buried waste at SWMU 4 (2.72E-03 versus 2.15E-04). This unexpected result implies that the content of the pits may not necessarily be the drivers for the SWMU-specific risks for these burial pits. However, the overall contribution to uncertainty of this heterogeneity is small.

  Another perspective on the heterogeneity associated with subsurface soil samples taken in and around the area of the pits is available when hazards and risks are calculated for individual sampling locations at SWMUs 4 and 6 and compared to those for the SWMUs as a whole. For example, in SWMU 6, there is considerable disparity between the location-specific risk associated with one location versus another. Thus, the risks associated with sampling location 006-010 are several orders of magnitude greater than others at the same SWMU. Sampling location 006-010 may therefore, in comparison to the ELCR applicable to the SWMU as a whole, be considered a risk driver ("hot spot") for this particular exposure pathway at this site.

- In this BHHRA, all analyte concentrations in water are from the analyses of unfiltered or total samples. The use of data from analyses of total samples is consistent with current EPA guidance (EPA 1989) but introduces an additional uncertainty to the BHHRA for some water-use pathways. The magnitude of the effect of this uncertainty upon the risk estimates is difficult to determine because the extent to which the quality of water (in terms of total solids) from a residential well could differ from the quality of water collected during the recent sampling effort is unknown. Because the groundwater samples used in this BHHRA were from boreholes, some samples had high solid content.

  The HI estimates calculated using unfiltered water from RGA and McNairy groundwater at WAG 3 SWMUs differed from those HIs calculated using *only* filtered samples by more than one order of magnitude in almost every case and, in some cases, up to three orders of magnitude. By contrast, the available ELCRs for filtered and unfiltered groundwater (RGA at SWMU 4) suggest only a small contribution to uncertainty. These results are consistent with the concept that the bulk of the turbid material removed from groundwater during filtering will be those inorganic components contributing most to the calculated systemic toxicity. In summary, the effect of this uncertainty on the ELCR determination is small, but medium-to-large for the HI determinations.

- Another factor in the risk assessment that makes a large contribution to uncertainty is the use of KDEP defaults versus site-specific estimates for the exposure duration and frequency at which a current industrial worker will be exposed to contamination at the subject SWMUs. Discrepancies in the computed ELCRs of close to three orders of magnitude may be an underestimation of the "true" differences between

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these pathway-specific risks because the actual exposure duration and frequency of a PGDP worker to surface soil at SWMUs 4, 5, and 6 is likely to be even less than the site-specific estimates used for this comparison.

F.1.2 BERA—PRINCIPAL FINDINGS

The three SWMUs comprising WAG 3 provide a small area of grassy habitat suitable for ecological receptors. The ecological risk assessment evaluates risks from current and potential future exposure of terrestrial plants, soil invertebrates, and terrestrial wildlife to chemicals in WAG 3 surface soil.

Chemical and radionuclide contaminants were evaluated for surface soils from SWMUs 4, 5, and 6. Table F.1.6 summarizes chemicals of potential ecological concern (COPECs) that were identified based on the results of screening contaminant concentrations against ecological benchmarks. Maximum concentrations of a number of analytes were near background levels or exceeded background levels or benchmarks at only a couple of stations.

Eleven nonradionuclide COPECs exceeded background levels and benchmarks for at least one receptor group at one or more SWMUs. The inorganics are aluminum, arsenic, chromium, copper, nickel, vanadium, and zinc; the organics are fluoranthene, phenanthrene, dibutylphthalate, and total PCBs. The list of 11 analytes is misleading because a number of analytes that exceeded a benchmark appear unlikely to pose a significant risk to terrestrial receptor populations. Aluminum and arsenic were within background in SWMUs 4 and 6 and had maximum concentrations of only 1.06× and 1.02× background, respectively, in SWMU 5. Neither is likely to pose a significant risk. With the exception of one station in SWMU 4, chromium was within or near background levels. Copper exceeded a benchmark at only one station in SWMU 4 and was otherwise below benchmarks and within background. Vanadium was detected above background at only one station. Fluoranthene and phenanthrene were above benchmarks at only one station, 005-015. Dibutylphthalate and PCBs were detected infrequently at concentrations resulting in exposures below lowest observed adverse effect levels (LOAELs) for wildlife. Chromium, nickel, and zinc appear to be the only potential ecological concerns for terrestrial receptors at relatively few stations at WAG 3.

Radionuclides in surface soil do not present a risk to terrestrial receptors at any of the SMWUs. Estimated doses from exposure to radionuclides in soil were below recommended dose rate limits for all receptors at all SWMUs.

The purpose of this assessment was to evaluate the likelihood that adverse ecological effects may occur or are occurring as a result of exposures at WAG 3. Analytes that are retained as COPECs may require further study to determine whether adverse ecological effects are likely if decisions for remedial actions are based on ecological concerns. Uncertainty concerning the future condition, the bioavailability or form of metals (e.g., arsenic, chromium), and use of only one line of evidence (comparison of exposures to single-chemical toxicity values) may lead to an overestimate of potential ecological risks.

A summary of analytes of potential concern and receptors potentially at risk is presented below by SWMU and in Table F.1.6.

- **SWMU 4**—Risks to terrestrial receptors at this SWMU are limited in extent. While chromium is generally below background levels and not a concern across the entire SWMU, the high concentration at Station 004-033 is a potential concern for plants, soil invertebrates, and wildlife. Nickel is also a potential concern for plants at Station 004-033 but not at other stations across the SWMU. Vanadium and zinc

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exceeded benchmarks for plants at one station each, but concentrations were within 1.3× background and are unlikely to be a real concern. PCBs slightly exceeded the no observed adverse effect level (NOAEL) for short-tailed shrews, but the exceedance was low and resulted in doses below LOAELs. Estimated doses from exposure to radionuclides in soil were below recommended dose rate limits for all receptors.

- **SWMU 5—**Risks to terrestrial receptors at this SWMU are limited in extent. Nickel poses a potential risk to plants at Station 005-009 but was within background at all other stations. Zinc is a potential concern to plants, soil invertebrates, and terrestrial wildlife (woodcock) primarily as a result of the elevated concentrations at Stations 005-007 and 005-002. However, even the maximum zinc concentration is within 2.5× background, and hazard quotients were low. Aluminum, arsenic, and chromium exceeded benchmarks, but all were within background at nearly all stations and none exceeded background levels by more than 1.3×. PCBs and dibutylphthalate resulted in dose estimates above NOAELs for shrews and woodcock, respectively, but neither exceeded a LOAEL. Estimated doses from exposure to radionuclides in soil were below recommended dose rate limits for all receptors.

- **SWMU 6—**Risks to terrestrial receptors are not expected from current or future exposures at this SMWU. Nickel and zinc exceeded benchmarks for plants, soil invertebrates, or wildlife, but both were within background at all stations except Station 006-001. Both were within 2.6× background at Station 006-001. Dibutylphthalate resulted in a dose estimate above the NOAEL for the woodcock but below the LOAEL. Estimated doses from exposure to radionuclides in soil were below recommended dose rate limits for all receptors.

Table F.1.1. Land uses and media assessed at WAG 3 SWMUs

Land use scenario	Site		
	SWMU 4	SWMU 5	SWMU 6
Current industrial worker			
Surface soil	X	X	X
Current terrestrial biota	X	X	X
Future industrial worker			
Surface soil	X	X	X
RGA groundwater	X	X	X
McNairy groundwater	X	X	X
Future excavation worker			
Surface and subsurface soil/waste	X	X	X
Future recreational user			
Soil (game)	X	X	X
Future on-site rural resident			
Surface soil	X	X	X
RGA groundwater	X	X	X
McNairy groundwater	X	X	X
Off-site rural resident			
Groundwater	X	X	X
Future terrestrial biota	X	X	X

Notes: Land use scenarios that were assessed in this baseline risk assessment are marked with an **X.**

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Table F.1.2. Land use scenarios for which human health risk exceeds *de minimis* levels

Land use scenario	Site		
	SWMU 4	SWMU 5	SWMU 6
Systemic toxicity[a]			
Current industrial worker			
Exposure to soil	X	—	—
Future industrial worker			
Exposure to soil	X	—	—
Exposure to RGA groundwater	X	X	X
Exposure to McNairy groundwater	X	X	X
Future on-site rural resident[a]			
Exposure to soil	X	X	X
Exposure to RGA groundwater	X	X	X
Exposure to McNairy groundwater	X	X	X
Off-site rural resident			
Exposure to groundwater	X	X	X
Future recreational user[a]			
Exposure to soil	—	—	—
Future excavation worker			
Exposure to soil and waste	X[c]	X[b]	X[c]
Excess lifetime cancer risk			
Current industrial worker			
Exposure to soil	X	X	X
Future industrial worker			
Exposure to soil	X	X	X
Exposure to RGA groundwater	X	X	X
Exposure to McNairy groundwater	X	X	X
Future on-site rural resident[d]			
Exposure to soil	X	X	X
Exposure to RGA groundwater	X	X	X
Exposure to McNairy groundwater	X	X	X
Off-site rural resident[e]			
Exposure to groundwater	X[e]	—	—
Future recreational user[d]			
Exposure to soil	—	X	—
Future excavation worker			
Exposure to soil and waste	X	X	X

Notes:
Land use scenarios where risk exceeded the benchmark levels (HI of 1/ELCR of 1.0E-06) are marked with an "X."
Land use scenarios where risk did not exceed a benchmark level are marked with a "—."
[a] Results for a child are presented for systemic toxicity for the future recreational user and the future on-site rural resident.
[b] These land use scenarios are of concern even though lead was not detected.
[c] Lead is present, and the land use scenario is of concern whether or not the element is included in the assessment.
[d] Values for excess lifetime cancer risk for the future recreational user and the future on-site rural resident are for lifetime exposure.
[e] Based on the results of contaminant transport modeling, "ς" indicates that the location contains a source of unacceptable off-site contamination.

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Table F.1.3. Summary of human health risk characterization for SWMU 4 without lead as a COPC

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker at current concentrations (soil)	5.4E-04	Beryllium Uranium-238	97 2	Dermal contact External exposure	97 2	3.62	Beryllium Chromium Iron Vanadium Barium	5 45 24 24 2	Dermal contact	99
Future industrial worker at current concentrations (soil)	5.4E-04	Beryllium Uranium-238	97 2	Dermal contact External exposure	97 2	3.62	Beryllium Chromium Iron Vanadium Barium	5 45 24 24 2	Dermal contact	99
Future industrial worker at current concentrations (RGA groundwater)	4.7E-04	Arsenic Beryllium 1,1-Dichloroethene Carbon tetrachloride Chloroform Trichloroethene Vinyl chloride	15 48 8 7 2 20 2	Incidental ingestion Dermal contact Inhalation while showering	72 18 10	32.6	Aluminum Arsenic Cadmium Chromium Iron Manganese Vanadium Carbon tetrachloride Trichloroethene	4 1 1 1 66 5 2 4 14	Ingestion Dermal contact Inhalation while showering	88 6 6
Future industrial worker at current concentrations (McNairy groundwater)	3.1E-03	Arsenic Beryllium	18 82	Ingestion Dermal contact	78 22	75.9	Aluminum Arsenic Barium Beryllium Cadmium Chromium Iron Manganese Vanadium	4 5 1 1 1 3 63 8 14	Ingestion Dermal contact	93 7
Future child rural resident at current concentrations (soil)	NA	NA	NA	NA	NA	98.2	Barium Beryllium Cadmium Chromium Iron Nickel Vanadium	2 2 2 24 60 2 9	Ingestion Dermal contact Ingestion of vegetables	1 21 78

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Table F.1.3 (continued)

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future child rural resident at current concentrations (RGA groundwater)	NA	NA	NA	NA	NA	487	Aluminum Arsenic Boron Chromium Iron Manganese Vanadium Carbon tetrachloride Chloroform Trichloroethene cis-1,2-Dichloroethene	3 1 1 1 49 3 1 10 1 29 1	Ingestion Dermal contact Inhalation while showering/household Ingestion of vegetables	40 1 30 29
Future child rural resident at current concentrations (McNairy groundwater)	NA	NA	NA	NA	NA	798	Aluminum Arsenic Barium Beryllium Cadmium Chromium Iron Manganese Mercury Vanadium Zinc	4 5 1 1 1 3 66 6 1 12 1	Ingestion Dermal contact Ingestion of vegetables	60 2 39
Future adult rural resident at current concentrations (soil)	4.3E-03	Beryllium Total PCBs Uranium-234 Uranium-238	72 5 6 17	Dermal contact External exposure Ingestion of vegetables	6 2 1	28.4	Barium Beryllium Cadmium Chromium Iron Nickel Vanadium	2 2 2 22 63 2 8	Dermal contact Ingestion of vegetables	14 85
Future adult rural resident at current concentrations (RGA groundwater)	7.0E-03	Arsenic Beryllium 1,1-Dichloroethene Carbon tetrachloride Chloroform Trichloroethene Vinyl chloride Technetium-99	8 22 15 7 5 20 2 21	Ingestion Dermal contact Inhalation while showering/household Ingestion of vegetables	26 3 30 41	158	Aluminum Arsenic Boron Chromium Iron Manganese Vanadium Carbon tetrachloride Trichloroethene	3 1 1 1 57 4 1 7 22	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	51 2 19 28

Table F.1.3 (continued)

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future adult rural resident at current concentrations (McNairy groundwater)	>1.0E-02*	Arsenic Beryllium Technetium-99	21 77 2	Ingestion Dermal contact Ingestion of vegetables	58 8 35	303	Aluminum Arsenic Barium Beryllium Cadmium Chromium Iron Manganese Vanadium Zinc	4 5 1 1 1 3 66 6 12 1	Ingestion Dermal contact Ingestion of vegetables	65 2 32
Future child recreational user at current concentrations (soil)	NA	NA	NA	NA	NA	< 1	—	—	—	—
Future teen recreational user at current concentrations (soil)	NA	NA	NA	NA	NA	< 1	—	—	—	—
Future adult recreational user at current concentrations (soil)	<1.0E-06	—	—	—	—	< 1	—	—	—	—
Future excavation worker at current concentrations (soil and waste)	2.7E-03	Arsenic Beryllium Total dioxins/furans Total PCBs Radium-226 Total uranium Uranium-238	1 7 4 2 2 83 1	Ingestion Dermal contact External exposure	37 10 54	2.61	Aluminum Arsenic Barium Beryllium Cadmium Chromium Iron Manganese Vanadium	8 4 2 2 1 24 24 14 20	Ingestion Dermal contact	13 87

Notes:
NA = ECLR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
– = There are no COCs or POCs.
* = The ELCR is approximate because the linearized multistage model returns imprecise values at risks >1.0E-02.

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Table F.1.4. Summary of human health risk characterization for SWMU 5 without lead as a COPC

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker at current concentrations (soil)	4.1E-04	Arsenic Beryllium Total PAHs	6 49 45	Ingestion Dermal contact	2 98	< 1	—	—	—	—
Future industrial worker at current concentrations (soil)	4.1E-04	Arsenic Beryllium Total PAHs	6 49 45	Ingestion Dermal contact	2 98	< 1	—	—	—	—
Future industrial worker at current concentrations (RGA groundwater)	5.4E-04	Beryllium 1,1-Dichloroethene Radium-226	35 1 64	Ingestion Dermal contact	90 9	26.8	Aluminum Barium Cadmium Chromium Iron Manganese Vanadium	4 1 1 2 73 16 2	Ingestion Dermal contact	96 4
Future industrial worker at current concentrations (McNairy groundwater)	1.2E-03	Beryllium Radium-226	42 58	Ingestion Dermal contact	89 11	63	Aluminum Cadmium Chromium Iron Manganese Vanadium	4 1 7 79 3 5	Ingestion Dermal contact	95 5
Future child rural resident at current concentrations (soil)	NA	NA	NA	NA	NA	46.2	Aluminum Arsenic Beryllium Chromium Nickel Zinc	24 53 1 17 3 1	Ingestion Dermal contact Ingestion of vegetables	1 12 87
Future child rural resident at current concentrations (RGA groundwater)	NA	NA	NA	NA	NA	283	Aluminum Barium Cadmium Chromium Iron Manganese Vanadium	4 1 1 2 77 12 1	Ingestion Dermal contact Ingestion of vegetables	61 1 37
Future child rural resident at current concentrations (McNairy groundwater)	NA	NA	NA	NA	NA	680	Aluminum Cadmium Chromium Iron Manganese Vanadium	4 1 6 81 3 4	Ingestion Dermal contact Ingestion of vegetables	60 1 39

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Table F.1.4 (continued)

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future adult rural resident at current concentrations (soil)	>1.0E-02*	Arsenic Beryllium Total PAHs Total PCBs	21 9 68 2	Dermal contact Ingestion of vegetables	9 90	13.9	Aluminum Arsenic Beryllium Chromium Nickel Zinc	24 55 1 15 3 1	Dermal contact Ingestion of vegetables	8 92
Future adult rural resident at current concentrations (RGA groundwater)	3.9E-03	Beryllium 1,1-Dichloroethene Radium-226 Technetium-99	33 4 57 5	Ingestion Dermal contact Inhalation while showering/household Ingestion of vegetables	56 3 4 37	107	Aluminum Barium Cadmium Chromium Iron Manganese Vanadium	4 1 1 2 76 13 1	Ingestion Dermal contact Ingestion of vegetables	67 2 31
Future adult rural resident at current concentrations (McNairy groundwater)	8.2E-03	Beryllium Radium-226	43 57	Ingestion Dermal contact Ingestion of vegetables	61 4 34	257	Aluminum Cadmium Chromium Iron Manganese Vanadium	4 1 6 81 3 4	Ingestion Dermal contact Ingestion of vegetables	65 2 33
Future child recreational user at current concentrations (soil)	NA	NA	NA	NA	NA	< 1	—	—	—	—
Future teen recreational user at current concentrations (soil)	NA	NA	NA	NA	NA	< 1	—	—	—	—
Future adult recreational user at current concentrations (soil)	1.0E-05	Arsenic Total PAHs Total PCBs	2 96 2	Ingestion of venison Ingestion of rabbit Ingestion of quail	16 63 21	< 1	—	—	—	—
Future excavation worker at current concentrations (soil and waste)	2.9E-04	Arsenic Beryllium Total PAHs Total PCBs	8 62 28 1	Ingestion Dermal contact	13 87	2.16	Aluminum Arsenic Barium Beryllium Chromium Iron Manganese	9 7 2 3 18 38 22	Ingestion Dermal contact	18 82

Notes:
NA = ECLR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
– = There are no COCs or POCs.
* = The ELCR is approximate because the linearized multistage model returns imprecise values at risks >1.0E-02.

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Table F.1.5. Summary of human health risk characterization for SWMU 6 without lead as a COPC

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker at current concentrations (soil)	2.4E-04	Beryllium Total PAHs	90 10	Dermal contact	99	< 1	—	—	—	—
Future industrial worker at current concentrations (soil)	2.4E-04	Beryllium Total PAHs	90 10	Dermal contact	99	< 1	—	—	—	—
Future industrial worker at current concentrations (RGA groundwater)	2.3E-04	Arsenic Beryllium Trichloroethene	15 74 11	Ingestion Dermal contact Inhalation while showering	76 22 2	19.1	Aluminum Arsenic Barium Cadmium Chromium Iron Manganese Vanadium Trichloroethene	3 1 1 2 2 61 20 3 6	Ingestion Dermal contact Inhalation while showering	92 6 2
Future industrial worker at current concentrations (McNairy groundwater)	7.8E-04	Arsenic Beryllium	24 76	Ingestion Dermal contact	79 21	41.7	Aluminum Arsenic Barium Cadmium Chromium Iron Manganese Vanadium	5 3 1 1 6 74 3 5	Ingestion Dermal contact	95 5
Future child rural resident at current concentrations (soil)	NA	NA	NA	NA	NA	9.38	Beryllium Chromium Nickel Zinc	8 72 15 5	Dermal contact Ingestion of vegetables	34 65
Future child rural resident at current concentrations (RGA groundwater)	NA	NA	NA	NA	NA	223	Aluminum Arsenic Barium Cadmium Chromium Iron Manganese Vanadium Trichloroethene	3 1 1 1 2 58 14 2 17	Ingestion Dermal contact Inhalation while showering/household Ingestion of vegetables	54 1 12 33

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Table F.1.5 (continued)

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future child rural resident at current concentrations (McNairy groundwater)	NA	NA	NA	NA	NA	451	Aluminum Arsenic Barium Cadmium Chromium Iron Manganese Vanadium	5 3 1 1 6 76 2 5	Ingestion Dermal contact Ingestion of vegetables	59 1 39
Future adult rural resident at current concentrations (soil)	2.4E-03	Beryllium Total PAHs	54 46	Dermal contact Ingestion of vegetables	30 69	2.57	Beryllium Chromium Nickel Zinc	7 70 17 6	Dermal contact Ingestion of vegetables	24 75
Future adult rural resident at current concentrations (RGA groundwater)	2.3E-03	Arsenic Beryllium Trichloroethene Technetium-99	12 51 16 21	Ingestion Dermal contact Inhalation while showering/household Ingestion of vegetables	41 6 8 46	79.9	Aluminum Arsenic Barium Cadmium Chromium Iron Manganese Vanadium Trichloroethene	3 1 1 1 2 61 15 2 12	Ingestion Dermal contact Inhalation while showering/househo ld Ingestion of vegetables	62 2 7 29
Future adult rural resident at current concentrations (McNairy groundwater)	5.7E-03	Arsenic Beryllium	28 72	Ingestion Dermal contact Ingestion of vegetables	59 7 34	170	Aluminum Arsenic Barium Cadmium Chromium Iron Manganese Vanadium	5 3 1 1 6 76 2 5	Ingestion Dermal contact Ingestion of vegetables	65 2 33
Future child recreational user at current concentrations (soil)	NA	NA	NA	NA	NA	< 1	—	—	—	—
Future teen recreational user at current concentrations (soil)	NA	NA	NA	NA	NA	< 1	—	—	—	—

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Table F.1.5 (continued)

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future adult recreational user at current concentrations (soil)	< 1.0E-06	—	—	—	—	< 1	—	—	—	—
Future excavation worker at current concentrations (soil and waste)	2.3E-04	Beryllium Total PAHs	90 9	Ingestion Dermal contact	5 95	2.44	Aluminum Barium Beryllium Chromium Iron Manganese Vanadium	8 2 3 15 32 15 26	Ingestion Dermal contact	12 88

Notes:
NA = ECLR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
– = There are no COCs or POCs.

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Table F.1.6. Summary of chemicals with maximum detected concentrations resulting in ecological hazard quotients greater than 1 for one or more nonhuman receptor groups

Receptor Group	Site		
	SWMU 4	SWMU 5	SWMU 6
Plants[a]	Chromium, nickel, vanadium[b], zinc[b]	Aluminum, arsenic[b], chromium, nickel[b], zinc	Nickel[b], zinc[b]
Soil invertebrates[a]	Chromium, copper	Chromium, zinc, fluoranthene, phenanthrene	Zinc[b]
Terrestrial wildlife[c]	Chromium	Aluminum	None

[a] Plant and soil invertebrate results are based on maximum detected concentrations or activities.
[b] Greater than background at only one station in the SWMU.
[c] Terrestrial wildlife results are based on comparison of maximum exposure estimates to lowest observed adverse effect levels.

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F.2. SOLID WASTE MANAGEMENT UNITS (SWMUS) 7 AND 30 OF WAG 22 SUMMARY

The baseline risk assessment results from the *Feasibility Study for Solid Waste Management Units 7 and 30 of Waste Area Group 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/06-1644&D2, are summarized below.

F.2.1 RISK ASSESSMENT SUMMARY

Human health and ecological risk assessments were completed as part of the 1997 RI. A BHHRA was performed to evaluate quantitatively potential risk associated with exposure to site contaminants for identified human receptors; whereas a SERA was performed qualitatively to assess potential ecological risk. Analytical data used in the BHHRA and SERA were obtained from previous investigations and the recent RI, including: (1) Phase I and Phase II Site Investigation analytical results for samples collected at SWMUs 7 and 30 from 1989 through 1991; (2) more recent RI analytical results for samples collected from June through November 1996; and (3) select results of routine groundwater monitoring at the PGDP. The latter data (i.e., routine monitoring data) was used only for groundwater inorganic and radionuclide background determinations. In addition, RGA groundwater data was evaluated as well as results of contaminant fate and transport modeling evaluation of risks associated with exposure to contaminants in groundwater. The potential for contaminants detected within the SWMUs to leach to groundwater is addressed in this FS.

The following subsections summarize results of the human health and ecological risk assessments. Risk results that are pertinent to the remedial action objectives (RAOs) established for this FS are the primary focus of the text, as these results support the purpose of remediation and the need for action. A summary of the uncertainty in the baseline risk assessment also is provided. More detailed information regarding the process for selecting COPCs, exposure assumptions used in the quantification of exposure, methods for toxicity assessment and risk characterization, and uncertainty analysis may be found in Volume 2 of the RI report. The last subsection discusses risk management decision-making completed to determine the need for action.

F.2.1.1 Baseline human health risk assessment

The BHHRA quantitatively evaluated potential risk associated with SWMUs 7 and 30 under current and future land use scenarios. Analytical data was subjected to a data evaluation and contaminant screening process that resulted in the identification of COPCs. Surface soil, subsurface soil, and sediment data were screened to identify soil COPCs. For risk assessment purposes, sediment samples that were collected in the north and south ditches were assumed to be surface soil. This is because surface-water flow in the ditches is intermittent, and the contents of the ditches are more representative of soil (DOE 1998). For the identification of COPCs in groundwater, RGA groundwater data was evaluated as well as results of contaminant fate and transport modeling completed in the RI. Modeling applications addressed contaminants that were present in pit soil or waste material at concentrations of concern for potential impacts to groundwater. Groundwater concentrations were simulated by a sequential application of two models, SESOIL and AT123D. The SESOIL model was used to simulate contaminant transport through the unsaturated zone from the burial pits and subsurface soils to the UCRS and subsequently to the RGA. The AT123D model then was used to simulate lateral transport through the RGA from beneath the source areas to the exposure points. The soil and groundwater COPCs included organic compounds, metals, and radionuclides. Summary statistics were completed that provided the range of detected concentrations, the frequency of detection, distribution, mean,

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and upper 95% confidence limit on the mean by medium for each SWMU and the North and South Ditches. These data subsequently were used for the determination of exposure-point concentrations in the exposure assessment portion of the BHHRA.

The exposure assessment portion of the BHHRA identified potential human receptor groups and potentially complete exposure routes for current and future exposure scenarios at SWMUs 7 and 30. Receptor groups were identified based on current industrial land use and projected future industrial land use in the area of the SWMUs. Site access and recreational use of the nearby WKWMA were considered during receptor identification. (Access by the general public is limited because the SWMUs are situated within the PGDP security fence.) In addition, although the future land use was assumed to be industrial, a future on-site residential scenario and a future on-site recreational scenario were considered in the receptor identification process to address risk management needs and to be consistent with KDEP risk assessment guidance. Potential human receptors identified in the BHHRA include: a current on-site industrial worker, a future on-site industrial worker, a future on-site rural resident (child and adult), a future on-site recreational user (child, teen, and adult), and a future on-site excavation (remediation) worker. To address exposure concerns due to potential off-site contaminant migration in groundwater, an off-site future rural resident also was evaluated. Furthermore, the potential recreational user considered was the local (rural) resident because it was determined that the individuals most likely to be recreational users are nearby residents.

In the exposure assessment, it was assumed that soil exposure for the industrial worker, on-site rural resident, and on-site recreational user is limited to the first foot of surface soil; and, therefore, the buried waste is not available for direct contact to these receptors. It was further assumed that the excavation worker may come into contact with the first 3 m (10 ft) of soil. Although groundwater at the site currently is not used as a drinking water source, the risk assessment assumed future groundwater use. Sediment in the North and South Ditches was assumed to be surface soil for purposes of site characterization as well as exposure assessment. Surface-water flow in the ditches was determined to be intermittent and not available for exposure.

Probable exposure routes to contaminants in soil, which were quantified for the current and future industrial worker, the future on-site rural resident, and the future excavation worker, include inadvertent ingestion, inhalation of VOCs or airborne soil particulates, dermal contact, and external exposure to ionizing radiation. Exposure routes quantified for the future recreational user were ingestion of game species including deer, rabbit, and quail. Probable exposure routes to contaminants in groundwater that were quantified for the future industrial worker and the future rural resident include ingestion of groundwater used as a drinking water source, inhalation of VOCs released from groundwater while showering, and dermal contact with groundwater contaminants while showering. Exposure to contaminated biota (i.e., garden vegetables) also was quantified for the future on-site rural resident.

Exposure was quantified by estimating chronic daily intakes (CDIs) of each COPC based on conservative exposure assumptions. Conservative EP A and KDEP default exposure parameters were used to calculate CDIs. Most of the regulatory agency default parameters are conservative in nature to prevent underestimation of risk and adverse health effects. Their application thus resulted in a conservative quantification of exposure or what is known as a reasonable maximum exposure (RME) scenario. Separate CDIs were calculated for systemic (noncarcinogenic) effects versus carcinogenic effects.

The potential toxicological effects of the COPCs were summarized in the toxicity assessment portion of the BHHRA. Toxicological effect summaries were provided for each COPC, which discussed potential noncarcinogenic (systemic) effects and potential carcinogenicity, as appropriate. The weight of evidence classification for carcinogens also was identified, as were the toxicity values used for the determination of

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noncarcinogenic hazard and carcinogenic risk. The toxicity associated with one particular COPC, lead, was evaluated using two toxicity assessment methods: one using provisional Rills provided by KDEP for oral, dermal, and inhalation toxicity; and a separate assessment of lead toxicity was completed using the EPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model. Results of both methods were provided in the risk characterization.

The risk characterization provided a quantitative estimate of potential noncarcinogenic hazard and ELCR associated with exposure to current concentrations of COPCs in environmental media at SWMUs 7 and 30 at the North Ditch and at the South Ditch. Risks for both current and future exposure scenarios were characterized. An assessment also was provided to evaluate potential hazards and risks to a future off-site receptor from exposure to contaminants potentially migrating in groundwater from the SWMUs.

The numeric estimate of the potential for noncarcinogenic effects posed by a single COPC within one exposure pathway was provided as a ratio of the CDI to the noncarcinogenic (RfD), expressed as the HQ. This term is not a statistical probability; rather, the noncancer HQ assumes there is a level of exposure (i.e., the RfD) below which it is unlikely for even sensitive populations to experience adverse effects. Generally, the greater the value above unity, the greater the level of concern. Swnming each COPC- specific HQ provided a noncarcinogenic HI for each exposure pathway (or exposure route) quantified for the individual receptor. The pathway-specific HIs were summed to give a total exposure HI for each exposure scenario. This approach assumes that simultaneous subthreshold exposures to several chemicals could result in an adverse health effect (i.e., total exposure HI > 1), and that the magnitude of the adverse effect could be proportional to the sum of the ratios of the subthreshold exposures to acceptable exposures (for chemicals exhibiting similar toxic effects). Results of noncarcinogenic hazard calculations can be found in Appendix A of Volume n of the RI.

The risk characterization for systemic toxicity (noncarcinogenic effects) determined that use of the provisional KDEP lead Rms resulted in a total exposure I-ll that was attributed primarily to lead exposure. Chemical-specific HQs indicated that the systemic toxicity calculated for lead overwhelmed the systemic toxicity calculated for other COPCs and, as a result, other COPC's additive effect to the total exposure became negligible (i.e., the lead HQ was far greater than any other chemical-specific HQ). To gain greater perspective and allow better interpretation of the estimated noncarcinogenic hazard, quantitative results without lead included as a COPC were presented in the uncertainty discussion of the BHHRA. Results of the IEUBK modeling effort, conducted for the future on-site child resident, suggested that combined exposure to concentrations of lead in soil and groundwater at SWMU 7 or at SWMU 30 would result in an unacceptable probability (> 5 percent) of the child blood lead level exceeding EPA's 10 µg/dL criterion (EPA 1991b). Modeling results for the South Ditch, where only surface soil at a representative concentration of 71 mg/kg was evaluated, suggested that lead is not a health concern for the child resident. Lead was not a soil COPC in the North Ditch. Representative concentrations of lead in soil and water also were compared to KDEP and EPA screening values (refer to Table 1.71 of Appendix A, Volume II of the RI). At SWMUs 7 and 30, representative concentrations of lead in surface and subsurface soil were greater than the KDEP value of 20 mg/kg, but less than the EPA value of 400 mg/kg. Concentrations of lead in groundwater at both SWMUs were greater than the KDEP and EPA criteria of 4 µg/l and 15 µg/l, respectively. Surface-water concentrations in the North and South Ditches and soil/ sediment levels of lead in the South Ditch were less than state and federal criteria.

For carcinogens, risks were quantified by estimating the incremental probability of an individual's developing cancer over a lifetime as a result of exposure to the COPC. The numeric estimate of ELCR was determined for each carcinogenic COPC by exposure pathway, and total pathway and total exposure ELCRs were determined by summation, similar to the summing of noncarcinogenic hazard. fu addition, the ELCRs

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determined for the child rural resident and for the adult rural resident were summed, as were the ELCRs for the child, teen, and adult recreational user, to give risk results for the rural resident receptor and recreational user receptor, respectively. The quantitative results for carcinogenic risk provided for the rural resident and recreational user in the tables thus conservatively assume the same individual is exposed to site contamination as a child, teen, and adult. Results of ELCR calculations can be found in Appendix A of Volume II of the RI.

Using conservative benchmark criteria, the risk characterization identified the use scenarios of concern, pathways of concern, media of concern, and COCs for SWMU 7, SWMU 30, the North Ditch, and the South Ditch. To determine use scenarios of concern, risk characterization results for total systemic toxicity (noncarcinogenic total exposure HI without the contribution from lead) and total risk (total exposure ELCR) for each use scenario were compared to benchmarks of 1.0 and 1×10^{-6} for HI and ELCR, respectively. For carcinogenicity, all of the current and future use scenarios evaluated at SWMUs 7 and 30 and at the North and South Ditches were of concern (i.e., total ELCR > 1×10^{-6} in all cases), except for the future recreational user scenario at the North Ditch. For systemic toxicity, only the recreational user (adult, teen, and child) scenario at the North Ditch and at the South Ditch and the rural resident at future modeled concentrations scenario were not of concern. As discussed in the uncertainty analysis below, quantitative results for lead were not included in the BHHRA observations.

Only those pathways with a pathway HI > 0.1 or a pathway ELCR > 1×10^{-6} within a use scenario of concern were identified as an exposure pathway of concern. If an exposure pathway was of concern, each medium involved in that pathway was deemed a medium of concern. Lastly, COCs were identified as those contaminants that had chemical-specific ELCRs summed over all exposure pathways within the use scenario of concern which were greater than or equal to 1×10^{-6} or whose HQs summed over all pathways within a use scenario of concern were greater than or equal to 0.1. Refer to the RI report for a complete discussion of pathways of concern and the list of COCs based on this guidance.

F.2.1.2 Uncertainty in the baseline human health risk assessment

Four broad types of uncertainties in the risk assessment process were discussed in the BHHRA: (1) uncertainties with data; (2) uncertainties with exposure assessment; (3) uncertainties with the toxicity assessment; and (4) uncertainties with the risk characterization. Specific uncertainties in each of these broad types of uncertainties were identified and the magnitude of the effect of the uncertainty on the risk characterization was categorized as small, moderate, or large. As defined in the BHHRA, uncertainties categorized as small should not affect the risk estimates by more than one order of magnitude; those categorized as moderate may affect the risk estimates by between one and two orders of magnitude; and those categorized as large may affect the risk estimate by more than two orders of magnitude.

Calculations were performed in the BHHRA to quantify several of the more significant uncertainties. Risks or hazards originally calculated using all default exposure values were recalculated using various alternative exposure assumptions.

The use of provisional lead RfDs provided by KDEP skewed the results for systemic toxicity by as much as three orders of magnitude. The systemic toxicity using the provisional RfDs was so large in comparison to other COPCs, that a comprehensive quantitative uncertainty analysis was completed in the BHHRA in order to determine the hazards presented by other COPCs (refer to Table 1.83 of the BHHRA; DOE, 1998).

In addition, tables from the quantitative uncertainty discussion omitted the contribution from lead to allow better interpretation of the systemic toxicity results for the other COPCs. The effect of using the provisional RfDs on the final risk estimates was large for systemic toxicity and small for ELCR. Observations

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presented in Section 1.7 of the BHHRA, Conclusions and Summaries, also did not include the quantitative risk contribution from lead.

Uncertainties with estimated moderate effects include uncertainties in estimating groundwater concentrations at points of exposure to off-site receptors (discussed in greater detail below); use of KDEP rather than EPA dermal absorption values; use of site-specific exposure values for the excavation worker and the current industrial worker; calculation of toxicity values for chemicals; and combination of chemical with radiological ELCRs.

Uncertainty was involved in characterizing exposure point concentrations under future conditions in the BHHRA. For example, the risk assessment does not consider that concentrations of some COCs may be lower at some time in the future due to processes such as degradation and attenuation or higher due to the potential for additional contaminant loadings over time in the future. To address this uncertainty, contaminant transport modeling was completed in the RI to estimate concentrations of selected COPCs in RGA groundwater beneath the unit and at downgradient points of exposure. The results were used as the basis of groundwater exposure point concentrations for the off-site rural resident. A conservative approach was used that may overestimate the contaminant concentration in the leachate. A source of uncertainty in the groundwater modeling effort is the assumption of contaminant concentrations in leachate, or source groundwater, used as the basis of SESOIL input. For simulating transport from the source areas to the UCRS, a conservative approach was used in which the maximum of either the observed contaminant concentration in soil or the soil concentration back-calculated from an observed source groundwater concentration, was used to represent the concentration in soil. As a result, chemicals that were not detected in source soil but that were detected in source groundwater sometimes were included in the modeling effort. (A discussion on back-calculating soil concentrations from groundwater concentrations was provided in Appendix D of the RI.) Additional uncertainty exists in the modeling of constituent concentrations from the UCRS to the RGA. For simulating transport from the UCRS to the RGA, the maximum predicted concentration in the UCRS was used as input to SESOIL, rather than using observed concentration data. In addition, this maximum concentration was assumed to be present throughout the lateral extent of HU 2 beneath the simulated source area or all of SWMUs 7 and 30. The BHHRA states that future risks calculated based on current concentrations were overestimated, and that the effect of this uncertainty is moderate

A separate modeling effort was conducted in the RI to estimate concentrations migrating in surface water. Although site-specific risk was not evaluated for actual or modeled surface-water concentrations because a complete exposure pathway to the intermittent surface-water flow in the ditches was not identified.

Default absorption factors for soil from KDEP were used in the BHHRA because chemical-specific absorption values were not available. The values provided by KDEP are much higher than those used in other risk assessments performed for the PGDP, where absorption factor defaults provided by EPA Region 4 were used. The effect of the uncertainty in the dermal absorption factor is moderate for the pathway estimates of systemic toxicity and ELCR and small for the total estimates of systemic toxicity and ELCR.

Uncertainty associated with the future excavation worker use scenario was evaluated in a pit-specific risk evaluation (included as Appendix E). fu the BHHRA, analytical results from all soil and waste samples collected from 0 to 3 m (0 to 10 ft) ft bls within a SWMU were used in determining exposure point concentrations for the excavation worker. As a result, the estimated exposure and the calculated ELCRs and systemic toxicity hazard represent excavation of the entire SWMU. To address this uncertainty and to improve remedial alternative evaluation, a separate pit-specific risk evaluation was completed for the unprotected excavation worker. Deriving the pit-specific ELCRs and systemic toxicity hazard to an excavation worker, the maximum detected concentrations of the SWMU-wide COPCs associated with each

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pit were used as the representative or exposure point concentration. The risk evaluation provided results using default and site-specific exposure parameters including and not including the systemic toxicity hazard from lead.

F.2.1.3 Screening ecological risk assessment summary

The primary purpose of the SERA was to narrow the scope of any future assessment activities by focusing on those aspects of a given site that constitute credible potential risks. Because only abiotic data are available for SWMUs 7 and 30, the SERA evaluated existing media data only. Within the SERA, the potential for ecological risks was identified by eliminating these:

- Particular chemicals or classes of chemicals as chemical of potential ecological concerns; Particular media as sources of contaminant exposure;

- Particular ecological receptors as assessment endpoints; or

- Ecological risks as a consideration during the planning of remedial actions.

A secondary purpose of the SERA was to identify situations that might require emergency responses No such situations were identified.

Twenty nonradionuclide COPECs (19 inorganics and Aroclor-1260) were retained for further evaluation at SWMU 7, while 17 (16 inorganics and Aroclor-1260) were retained at SWMU 30. Sixteen nonradionuclides (15 inorganics and Aroclor-1260) were retained for further evaluation at the ditches. Radionuclides (principally ^{234}U and ^{235}U) were retained at SWMUs 7 and 30 and the South Ditch because of potential risks to plants.

The purpose of the SERA was to eliminate analytes for which adverse ecological effects are not expected. Analytes that were retained as COPECs may require further study to determine if adverse ecological effects are likely if remedial action decisions will be based on ecological concerns. These analytes will be investigated further during the site- wide baseline ecological risk assessment to be performed as part of the SWOU study (WAGs 18 and 25). Additionally, cumulative effects to ecological receptors will be evaluated during this study.

F.2.1.4 Risk management to determine the need for action

In order to determine if a need for remedial action exists at SWMUs 7 and 30, the results of the BHHRA and SERA are evaluated for risk management purposes. The purpose of this section is to provide an objective evaluation of the potential risks that may be associated with possible exposure to contaminated environmental media at or potentially migrating from SWMUs 7 and 30.

The most likely future land use at SWMUs 7 and 30 is on-site secured industrial owned by DOE, based on land use information provided in the SMP and the fact that the SWMUs are situated within the PGDP security fence. The DOE will develop a LUCAP to ensure that institutional controls necessary to ensure SWMUs 7 and 30 remain on-site secured industrial owned by DOE are effective in the long-term. Therefore, secured industrial land use/DOE property ownership is the future land use for SWMUs 7 and 30 that is the basis of risk management decision making in this FS. Only those exposure scenarios evaluated in the baseline risk assessment that are most applicable to future land use are considered when evaluating possible remedial alternatives. The industrial worker and the excavation worker scenarios are applicable to on-site exposure

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concerns at SWMUs 7 and 30; whereas the future on-site rural resident and the future on-site recreational user exposure scenarios are not applicable and are not considered further in this FS.

Other exposure scenarios that are included in this evaluation are the current industrial worker and the future off-site rural resident. The current industrial worker exposure scenario is considered to provide supporting information to the evaluation of the future industrial worker. The exposure evaluated for the future industrial worker in the BHHRA assumed an industrial use at SWMUs 7 and 30 other than continuation of current activities, and future on-site groundwater use was assumed. According to the SMP, future exposure to the industrial worker actually is not anticipated to change from the current scenario, based on the projected future land use and due to existing institutional controls at the unit. The risk results for the current industrial worker exposure scenario are, therefore, considered applicable for the future industrial worker receptor in this FS. In addition, the PGDP does not plan to use groundwater in the future, as an alternate water supply is provided by DOE under the water policy. Because of the water policy and the projected future land use, groundwater use by the future industrial worker Is not deemed applicable for risk management decision making and will not be considered further. (As previously mentioned, the DOE also will prepare a LUCAP to ensure the long-term effectiveness of institutional controls necessary to protect human health an the environment at SWMUs 7 and 30 in the future.) The risk results for the current industrial worker also are useful, because groundwater exposure was not addressed for the current industrial worker in the BHHRA.

Although groundwater is not a medium to be addressed in this FS because it will be addressed by the GWOU according to the SMP, the potential for contaminants detected in soil/waste within the SWMUs to migrate to groundwater and offsite (i.e., groundwater that is moving outside of the DOE property boundary) is addressed in this FS. Therefore, the off-site rural resident also is considered in an applicable exposure scenario for risk management decision making and development of remedial actions. As discussed earlier, groundwater exposure point concentrations for the off-site groundwater exposure scenario were estimated using results of fate and transport modeling in the RI and refined further in this FS in Appendix F.

Using the Region IV EPA criteria, use scenarios of concern, pathways of concern, and COCs are identified for SWMUs 7 and 30 and the North and South Ditches. Only applicable use scenarios are evaluated (current industrial worker, future industrial worker, future excavation worker, and off-site rural resident). Because of the uncertainty associated with the noncarcinogenic HQ results for lead, lead is not included as a COPC. Elimination of lead from further consideration as a soil COPC in the FS is supported by the results of the EPA IEUBK model completed in the BHHRA, which suggests that concentrations of lead in soil at SWMUs 7 and 30 are not a significant health concern. Results of the IEUBK model indicated that concentrations of lead in on-site groundwater at SWMUs 7 and 30 are unacceptable, although the c:oncentrations were not of concern for off-site migration potential. Soil concentrations alone at SWMUs 7 and 30 likely would not result in an unacceptable probability (> 5 percent) of the child blood lead level exceeding EPA's 10 µg/dL criterion, because the detected soil concentrations are no greater than the representative concentration of 71 mg/kg modeled for the South Ditch, which did not suggest a health concern for the conservative on-site child resident receptor.

To improve interpretation of the risk results and to meet specific needs of this FS, modifications to the exposure scenarios completed in the BHHRA uncertainty analysis are incorporated into the risk management decision making process. Such changes and impacts to risk results were summarized earlier. Modifications to the risk results for the future industrial worker in this FS (i.e., use of results for the current scenario) were discussed above. Additional modifications were made as part of this FS to more closely evaluate pit-specific concerns, such as a burial pit-specific risk characterization for a future excavation worker (included in Appendix E of the FS report) and an evaluation of contaminant loading from individual burial pits within SWMUs 7 and 30 for the off-site groundwater exposure scenario. As a result, some risk estimates differ from

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what was presented in the BHHRA. These modified risk estimates are used in defining the need for potential remedial action and for evaluating remedial alternatives in this FS.

The following discussion addresses risk management decisions for applicable use scenarios at each SWMU and the North and South Ditches. A separate discussion for off-site groundwater also is provided. As noted above, modified risk results from the uncertainty analysis are used for risk management decision making and on-site exposure to groundwater was not considered applicable.

F.2.1.4.1 Solid Waste Management Unit 7

In the BHHRA, uncertainty associated with the use of default exposure parameters for the current industrial worker and the future excavation worker was addressed by modifying the intake calculations using site-specific or average values. The current industrial worker exposure frequency (EF) and exposure duration (ED) were adjusted from the KDEP default 250 days per year EF for 25 years ED to researched site-specific values that address combined groundwater sampling and routine maintenance activities, such as grass mowing, being conducted by PGDP employees at SWMUs 7 and 30. The site-specific values that were used for the industrial worker are 16 days per year EF for 25 years ED. Similarly, the highly conservative KDEP default values for the excavation worker of 185 days per year EF for 25 years ED were adjusted. The excavation scenario typically represents a soil removal action associated with construction of a foundation or excavation of contaminated soil. For nearly all waste sites or foundation construction sites, this is a one time event. The excavation worker exposure parameters were adjusted to site-specific values for each SWMU based on the SWMU volumes to 170.5 days per year EF for two years ED at SWMU 7 and 226 days per year EF for one year ED at SWMU 30.

Uncertainty associated with the use of default values when estimating absorbed dose were addressed in the BHHRA by using EPA default dermal absorption exposure values in place of KDEP values. This is in accordance with the Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant. Modifications to the dermal pathway absorbed dose estimates were made to the current and future industrial worker use scenarios, as well as to the future excavation worker use scenario.

Resultant modification of the total exposure ELCRs for the current industrial worker, future industrial worker, and future excavation worker showed a reduction of estimated potential risk to 1×10^{-5}, 2×10^{-4}, and 7×10^{-6}, respectively (refer to Table 2-8). Modification to total exposure HIs resulted in reduction of the HIs for the current industrial worker, future industrial worker, and future excavation worker from an HI of 5 in all cases to HIs of 0.02, 0.3, and 0.008, respectively (refer to Table 2-9). Because the future industrial worker total exposure ELCR of 2×10^{-4} is the only modified result that is greater than the 1×10^{-4} ELCR and 1.0 HI EPA thresholds, this use scenario is the only use scenario of concern remaining at SWMU 7. However, the default exposure frequency and duration were not modified for the future industrial worker in the BHHRA uncertainty analysis. As stated earlier in this FS, the future industrial use at SWMUs 7 and 30 assumed for this FS is continuation of current activities (i.e., groundwater sampling and routine maintenance). Therefore, the future industrial worker's exposure is assumed to be equal to that of the current industrial worker for risk management purposes. Because the modified results for the current industrial worker, which used the site-specific EF and ED to address the current sampling and maintenance activities being conducted at SWMUs 7 and 30 are below the EPA thresholds, no use scenarios of concern are identified at SWMU 7. In addition, conservative application of the gamma walkover data to risk evaluation (refer to Appendix G of the FS) supports the elimination of the industrial worker use scenario. Characterization of radiation concerns using a walkover survey and site-specific exposure assumptions found that the average dose to an industrial worker over both SWMUs is approximately 6 mrem/yr (refer to Appendix G of the FS), which is well below all

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pertinent radiation protection standards. Any change in the assumed future industrial use at SWMU 7 may, however, present unacceptable carcinogenic risk to a future industrial worker.

Based on the modifications to risk results and assuming future land use is consistent with that proposed in the SMP (secured industrial/DOE-owned), the future excavation worker is not a use scenario of concern at SWMU 7. The pit-specific risk evaluation for an unprotected excavation worker at SWMU 7 (refer to Appendix E of the FS) examined exposure to contaminants during excavation of Pits B/C, Pit D, or the F Pits. Results based on site-specific exposure and not including lead indicate that any intrusive activities at Pits B/C and the F Pits within SWMU 7 must be accompanied by a health and safety plan that recognizes the unacceptable hazards to an unprotected excavation worker. Health and safety restrictions for Pit D should be considered if the exposure rate is greater than that used in the site-specific assessment. fu addition, worker protection measures may be necessary to address the maximum concentration of lead at SWMU 7, found at Pits B/C at a level exceeding the EPA soil lead screening value. A discussion of subsurface material contribution to off-site groundwater risks is provided in a following subsection.

F.2.1.4.2 Solid Waste Management Unit 30

As for SWMU 7, the modified results that address exposure uncertainties (refer to Tables 2-8 and 2-9) are used for risk management at SWMU 30. Resultant modification of the total exposure ELCRs for the current industrial worker, future industrial worker, and future excavation worker again showed a reduction of estimated potential risk to 1×10^{-5}, 2×10^{-4}, and 7×10^{-6}, respectively (refer to Table 2-8). Modification to total exposure HIs resulted in reduction of the HIs for the current industrial worker, future industrial worker, and future excavation worker from an I-ll of four in all cases to His of 0.01, 0.2, and 0.04, respectively. Because the future industrial worker total exposure ELCR of 2×10^{-4} is the only modified result that is greater than the 1×10^{-4} ELCR and 1.0 HI EPA thresholds, this use scenario is the only use scenario remaining at SWMU 30. However, the default exposure frequency and duration were not modified for the future industrial worker in the BHHRA uncertainty analysis. As stated earlier in this FS, the future industrial use of the site is assumed to be continuation of current activities (i.e., groundwater sampling and routine maintenance); therefore, the future industrial worker's exposure is assumed to be equal to that of the current industrial worker for risk management purposes. Because the modified results for the current industrial worker, which used the site-specific EF and ED to address current sampling and maintenance activities being conducted at SWMU 30, are below the EPA thresholds, no use scenarios of concern are identified at SWMU 30. Conservative application of the gamma walkover data to risk evaluation (refer to Appendix G of the FS) supports the elimination of the industrial worker use scenario. Characterization of radiation concerns using a walkover survey and site-specific exposure assumptions found that the average dose to an industrial worker over both SWMUs is approximately 6 mrem/yr (refer to Appendix G of the FS), which is well below all pertinent radiation protection standards. Any change in the assumed future industrial use at SWMU 30 may, however, present unacceptable carcinogenic risk to a future industrial worker.

The future excavation worker is the only receptor who may come into contact with subsurface contaminants at SWMU 30. Based on the modifications to risk results and assuming future land use is consistent with that proposed in the SMP (secured industrial/DOE-owned), the future excavation worker is not a use scenario of concern at SWMU 30. The pit-specific risk eyaluation for an unprotected excavation worker at SWMU 30 (refer to Appendix E of the FS) examined exposure to contaminants during excavation of Pit A or Area Z, the former incinerator area. Results based on site-specific exposure and not including lead indicate that intrusive activities at Pit A or Area Z would not present an unacceptable risk using the EPA Region N criteria. Health and safety restrictions should be considered if the exposure rate is greater than that used in the site- specific assessment. fu addition, worker protection measures may be necessary to address the maximum concentration of lead at SWMU 30, detected within Pit A at a level exceeding the EPA soil lead

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screening value. A discussion of subsurface material contribution to off-site groundwater risks is provided in a following subsection.

F.2.1.4.3 North Ditch

The North Ditch risk results for exposure to contaminants in ditch sediment/ surface soil were modified to address exposure uncertainties. Resultant modification of the total exposure ELCRs for the current industrial worker and future industrial worker showed a reduction of estimated potential risk to 2×10^{-6} and 3×10^{-5}, respectively (refer to Table 2-8). Modification to total exposure HIs resulted in reduction of the HIs for the current industrial worker and future industrial worker from an HI of 5 in both cases to HIs of 0.01 and 0.2, respectively (refer to Table 2-9). None of these modified results exceeds the 1×10^{-4} ELCR and 1.0 HI EPA thresholds. The excavation worker use scenario was not evaluated at the North Ditch and is, therefore, not applicable. Based on the modified risk results and assuming continuation of current activities for the future industrial scenario, surface action of the North Ditch is not warranted.

As pointed out in the BHHRA, there is uncertainty associated with characterizing exposure point concentrations under future conditions. The quantification of exposure for contaminants in surface soil at the North Ditch used current sediment concentrations as the basis of exposure point concentrations. In calculating exposure point concentrations, the concentrations of COPCs were assumed to be constant throughout the exposure period. As a result, the risk assessment did not consider that concentrations of some soil COPCs may be lower at some time in the future due to degradation or attenuation or higher due to the potential for additional contaminant loadings over time in the future. To evaluate uncertainty associated with characterizing soil exposure point concentrations under future conditions at the North and South Ditches, potential sediment loading to the drainage ditches from SWMUs 7 and 30 runoff was examined (refer to Appendix D of the FS). The MUSLE model was applied to determine sediment yield to the drainage ditches. Appendix D contains greater detail of input parameters and calculations. The results of the calculations indicated that SWMUs 7 and 30 contribute minimal sediment to the adjacent drainage systems, and it was concluded that contaminant loading from the SWMUs from overland transport should be minimal as long as a vegetative cover is maintained.

The intermittent surface water in the ditches comes from: (1) runoff from precipitation, which is the main contributor to flow during high flow following rain events, and (2) discharge of shallow groundwater which is the main contributor during dry periods when only moist soil conditions exist in the ditch beds. Because flow is intermittent and not consistently available for contact, a complete exposure pathway to surface water in the ditches was not identified for human or ecological receptors. Modeling applications completed in Section 5.5.2 of the RI simulated the off-site migration of certain COPCs from overland flow of runoff at the SWMUs through the North And South Drainage Ditches. Although the results indicated that ^{99}Tc would be a problem in surface water at the site from overland flow, the MUSLE model indicates that sediment loading to the surrounding ditches from the soil of SWMUs 7 and 30 is insignificant. Shallow groundwater discharging to the ditches is not expected to be a migration pathway because the clay soil around the burial pits fosters vertical subsurface migration.

The ditches drain to Bayou Creek through KPDES permitted Outfall 001. This outfall receives treated waste waters from the C-752 Waste Storage and Treatment Building, the C-616 Wastewater Treatment Facility, the Vortec Vitrification Project, and C-617 Northwest Plume Interim Remedial Action Pilot Plant and untreated waste waters from various sources including runoff from SWMUs 7 and 30. As part of the Biological Monitoring Program, effluent toxicity (biological) testing is completed at Outfall 001 on a quarterly basis. An annual report has not yet been released for 1997, but review of monthly 1997 discharge monitoring reports for Outfall 001 found no unacceptable contaminant levels. The DOE will continue these

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programs to ensure protection of human health and the environment in the future. Existing contamination in the ditches surrounding SWMUs 7 and 30 will be addressed under the sitewide SWOU.

F.2.1.4.4 South Ditch

As before, the South Ditch risk results were modified to address exposure uncertainties (refer to Tables 2-8 and 2-9). Resultant modification of the total exposure ELCRs for the current industrial worker and future industrial worker showed a reduction of estimated potential risk to 3 x 10^{-6} and 5 x 10^{-5}, respectively. Modification to total exposure HIs resulted in reduction of the HIs for the current industrial worker and future industrial worker from an HI of five in both cases to HIs of 0.01 and 0.2, respectively (refer to Table 2-9). None of these modified results exceeds the 1 x 10^{-4} ELCR and 1.0 HI EPA thresholds. The excavation worker use scenario was not evaluated at the South Ditch and, therefore, was not applicable. Based on the modified risk results and assuming continuation of current activities for the future industrial scenario, surface action of the South Ditch is not warranted.

As mentioned above, there is uncertainty associated with exposure point concentrations used in the BHHRA for future exposure. However, modeling results of potential sediment loading to the drainage ditches from SWMUs 7 and 30 runoff (refer to Appendix D of the FS) indicated that SWMUs 7 and 30 contribute minimal sediment to the adjacent drainage systems. Contaminant loading to the North and South Ditches from overland transport should be minimal as long as a vegetative cover is maintained.

Because flow in the ditches is intermittent and not consistently available for contact, a complete exposure pathway to surface water in the ditches was not identified human or ecological receptors. As discussed in the risk management text for the North Ditch, a horizontal flow component in the UCRS may exist, the subsurface clays surrounding the pits primarily foster vertical migration. There also has been no unacceptable reporting at the nearby Outfall 001 (refer to North Ditch text above). The DOE will continue these programs to ensure protection of human health and the environment in the future. Existing contamination in the ditches surrounding SWMUs 7 and 30 will be addressed under the sitewide SWOU.

F.2.1.4.5 Off-site groundwater

The BHHRA used the RI groundwater modeling results to estimate potential risks associated with future use of RGA groundwater as a drinking water source by an off-site rural resident. In the RI, migration of contaminants to the UCRS and RGA were simulated by applying the SESOIL Model and lateral migration within the RGA was simulated by applying the AT123D Model. Predicted peak concentrations in 30 years and in 100 years at the DOE property boundary were provided. Application of the modeled chemical concentrations at the DOE property boundary as groundwater exposure point concentrations for risk assessment resulted in the identification of the future off-site rural resident 100-year groundwater concentration scenario being selected as a use scenario of concern. Selection of this use scenario is based on the total ELCR of 2 x 10^{-4} which exceeds the EPA threshold of 1 x 10^{-4}. Noncarcinogenic HIs for all scenarios evaluated were less than the EPA threshold of 1 for systemic effects. Pathways of concern for the future rural resident at the 100-year concentrations are ingestion of groundwater and inhalation of VOCs from household use. The COCs include a TCE degradation product, vinyl chloride, and a radionuclide, ^{99}Tc.

Chemicals that were selected for groundwater transport modeling in the RI were chosen using a separate data screening process than what was used in the BHHRA to identify COPCs (refer to Section 5.0 of the RI). The RI screening process incorporated comparison to several criteria including soil screening levels for the protection of groundwater, soil and groundwater RBCs, and ARARs. The screening process also used conservative procedures for evaluating observed versus predicted chemical concentrations. Identification of

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constituents that were carried forward in each step of the modeling effort was based on observed soil and groundwater concentrations as well as the predicted concentrations in soil and groundwater, with conservatism applied to the selection process by using the higher of the two values. As a result, chemicals that were not detected in source soil were sometimes included in the modeling effort based on source groundwater concentrations, and the soil concentration was back-calculated from the source groundwater concentration.

For example, the COC vinyl chloride was not detected in source soil at SWMUs 7 and 30, but it was detected in source groundwater. It was not selected for SESOIL modeling to the UCRS, however, because chemicals that were currently in the UCRS groundwater with concentrations higher than in the source area groundwater were excluded from leachate modeling to the UCRS. Because the UCRS concentration was greater than the groundwater RBC, vinyl chloride was selected for vertical transport modeling to the RGA. Inclusion of vinyl chloride in the modeling effort to off-site receptors allows a conservative evaluation that addresses the potential continued degradation of TCE in UCRS groundwater and the possible off-site migration of this degradation product. However, no observed concentrations of vinyl chloride were reported in the RGA groundwater beneath the units. The RI also indicates that TCE is not being degraded in the RGA based on the relative concentrations of TCE and its degradation products in RGA groundwater samples. In summary, the predicted RGA groundwater concentrations of vinyl chloride at the DOE property boundary are based solely on concentrations detected in the UCRS and they are still well below the MCL for vinyl chloride. As noted earlier, this FS addresses sources of contamination at SWMUs 7 and 30; and existing contamination in the UCRS and the RGA groundwater are being addressed under the GWOU. The low hydraulic conductivity of UCRS soils generally makes remedial measures infeasible. Additionally, the UCRS soils offer significant natural attenuation potential in some areas of the PGDP, including the SWMUs 7 and 30 areas. Thus, deferral to a remediation strategy for the GWOU makes sense. Moreover, the remedial measures are intended to address sources of contamination. The contaminated UCRS groundwater, alone, does not present an appreciable risk; therefore, it is not included in the basis of recommended remedial action at SWMUs 7 and 30.

The BHHRA states that the results of SESOIL and AT123D modeling indicate that future risk calculated under current concentrations were overestimated, and that the effect of this uncertainty is moderate (DOE 1998). Further fate and transport applications for ^{99}Tc were completed in the RI, and as part of this FS, which refine the modeling and improve the interpretation of future risk. The RI report concluded that ^{99}Tc was the only constituent that will continue to migrate from soils through groundwater to potential off-site exposure points at concentrations that are unacceptable. Therefore, further fate and transport applications were completed in the RI to address the source units within SWMUs 7 and 30 separately, in terms of contaminant contributions to the receptor locations (refer to Section 5.5.1.4 of Volume I and RI Table 5.17). Predicted ^{99}Tc concentrations in the RGA based on future contaminant loading from the individual source units were examined. Contaminant loading from the individual pits was modeled and predicted groundwater concentrations at the PGDP security fence and at the DOE property boundary were determined, along with the percent of the total contribution for each source unit. The results indicated that approximately 0.4% of the total ^{99}Tc at the DOE property boundary in 100 years would be from Pit A; approximately 19.1% would be from Burial Pits B and C; approximately 0.07% would be from the F-series Burial Pits; and 80.43% would be from subsurface soils surrounding the burial pits. The subsurface soils outside the burial pits were shown to have the highest percent contribution to off-site ~c groundwater concentrations, because the modeling used the maximum detected soil concentration, which was found at the incinerator area (Area Z), and assumed contaminant loading from the entire area within the two SWMUs that surround the burial pits. Otherwise, Burial Pits B and C were shown to be the burial pits contributing most to the off-site ^{99}Tc contamination.

The source unit specific modeling conducted for ^{99}Tc in the RI was augmented as part of this FS (refer to Appendix F). Each source unit's potential contaminant loading to RGA groundwater was again examined,

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except a few changes were made. Unlike the SWMUs 7 and 30 RI report, where contributions from multiple sources were combined prior to modeling the concentrations expected at exposure points, contributions from all sources were modeled separately from their origin to the exposure point. In addition, values used for several modeling parameters differ from those used in the RI. Each of the four source units addressed in the RI were reexamined (Pit A, Pits B/C, F Pits, and surrounding soils), and an additional source unit was included to address the incinerator area (Area Z). The incinerator area was delineated as a separate source, rather than being grouped with the surrounding soils area. In addition, the source mass was based on RI soil concentration data (the lesser of the upper 95th confidence limit on the mean concentration or the maximum concentration) rather than concentrations estimated from source groundwater levels (i.e., back-calculated soil concentrations were not used). Values derived from groundwater concentrations that were used in the RI report are greater than observed soil concentrations used in the augmentation. Sensitivity of the results to model parameters was analyzed. An empirical approach to sensitivity analysis was used to limit the number of model iterations necessary. (Refer to Appendix F.)

Model results were produced every five years from zero to 100 years in order to examine the timing of peak concentrations and investigate model dynamics. Model results are provided in Appendix F (refer to Table 10 of the report). The initial run used the more conservative parameters for recharge rate and source mass. This initial run indicated that none of the source units (Pit A, Pits B/C, F Pits, surrounding soils, or the incinerator area) would contribute concentrations of ^{99}Tc that would be greater than its derived MCL (900 pCi/l) at the receptor exposure point (DOE property boundary). Pit G is assumed to be the same as Pits B/C, and, therefore, also would not contribute unacceptable concentrations. In fact, no exceedances of the derived MCL were shown beneath the units or at the PGDP security fenceline. Because none of the modeled source units had an MCL exceedance, no additional runs were necessary .

F.2.1.4.6 Ecological concerns

The SERA culminated in the identification of surface soil COPECs for each of SWMU 7, SWMU 30, the North Ditch, and the South Ditch. Chemicals of potential ecological concern were associated with hazards to soil microbes, plants, earthworms, a representative herbivore (white-tailed deer), a representative omnivore (white-footed mouse), and a representative vennivore (short-tailed shrew). The SERA was based on ecological benchmarks derived from conservative exposure assumptions. Due to the current and future industrial nature of SWMUs 7 and 30, actual ecological risks are estimated to be limited. The SWMUs are located within the facility boundaries inside the PGDP security fence. Neither critical habitats nor federal or state threatened and endangered species are present inside the PGDP boundary. Additionally, no waterfowl or fish are present permanently in the ditches surrounding SWMUs 7 and 30. It is inappropriate to assess direct toxic effects on wildlife populations for these source units due to the industrial nature and small scale of the SWMUs. The cumulative effects of small losses or contamination of terrestrial habitat will be assessed facility-wide (or watershed-wide) in the PGDP baseline ecological risk assessment for the SWOU.

F.2.1.4.7 Summary

Use scenarios of concern for risk management decision-making were identified using EPA Region 4 threshold values. There were no use scenarios of concern identified at SWMUs 7 and 30 based on the modified risk results. Consequently, there also were no COCs identified. Evaluation of the risk results during the risk management decision- making process indicated that remedial action at SWMUs 7 and 30 is not warranted. Modeling results indicate that ^{99}Tc concentrations in the RGA beneath the unit and at the nearest point of exposure, the DOE's-property boundary, were below its derived MCL (900 pCi/I). The predicted maximum ^{99}Tc concentration at the DOE property boundary was 21 pCi/l, an order of magnitude less than its derived MCL, indicating that the risk for the future off-site rural resident likely would be in the 10-6 range and also below the EPA threshold.

There also has been no unacceptable reporting at the nearby Outfall 001 (refer to North Ditch text above). The DOE will continue these programs to ensure protection of human health and the environment in the future. Surface-water and groundwater concerns (e.g., the possible presence of DNAPL in the soil beneath SWMUs 7 and 30) identified during the RI, BHHRA, or SERA will be addressed under the SWOU and GWOU, respectively.

The two SWMUs, 7 and 30, currently are posted as radiologically contaminated areas and are surrounded by demarcation rope to limit access. While the areas do not pose a radiation risk based on the modified exposure assumptions previously discussed, the posted areas represent an administrative tracking concern and ensure limited access to the unit.

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F.3. SWMUS 2 AND 3 OF WAG 22 SUMMARY

The following is a summary of the baseline risk assessment found in the *Remedial Investigation Addendum for Waste Area Grouping 22, Burial Grounds Solid Waste Management Units 2 and 3 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1141&D2.

F.3.1 DATA ANALYSIS

The soil samples are considered representative of the soil conditions at the perimeter of the C-749 Uranium Burial Ground and C-404 Low-Level Radioactive Waste Burial Ground and provide sufficient data for a quantitative assessment of the Reasonable Maximum Exposure (RME) concentration for soils around the units. A reasonable deviation is that higher concentrations of contaminants are present in small, localized areas below ground surface (bgs) that may not have been detected in this analysis.

No data have been collected for the waste materials or soils within the burial pits because of the potential health and safety threat to investigation workers. In addition, SWMU 2 has a 6-in. clay cap over the wastes, and SWMU 3 has a multilayer RCRA cap over the waste. A quantitative assessment of risks cannot be made for the waste pits themselves.

Only constituents available for potential receptor contact (i.e., detected in the upper 6 ft of soil and in groundwater from the well associated with the highest risk estimate) were evaluated in the risk assessment. Data for the risk assessment were validated, and no rejected data were used in this assessment.

Results of sampling of downgradient groundwater in MW-58 and -154 at SWMU 2 and MW -93 and -94 at SWMU 3 confirm the presence of contaminants in the UCRS and RGA and are used to support evaluation of potential releases from these units. Recognizing the uncertainty in the spatial distribution of contaminants in groundwater, These data are used to screen potential risks to groundwater from releases of contaminants from SWMUs 2 and 3. A more detailed evaluation of groundwater conditions will be performed with evaluation of the onsite groundwater integrator unit. That analysis will consider in greater detail the spatial distribution of contaminants in these groundwater units and the sources of contamination from multiple waste areas.

Available data verify releases from SWMUs 2 and 3 to soils and groundwater and support the source characterization. Solvents are generally not persistent in unsaturated soils; risk estimates are based on the measured levels of contaminants in these monitoring wells rather than on a modeled concentration.

F.3.2 CURRENT ONSITE LAND USE

SWMUs 2 and 3 are onsite waste areas located inside of the secured fenced area of PGDP. The perimeter fence is patrolled, and public access would not be expected to occur .The combined contaminated area is approximately 85,200 ft^2 .As previously stated, SWMU 2 has a 6-in. clay cap, and WMU 3 has a multilayer RCRA cap. Although periodic maintenance activities occur at the site, routine daily activities do not. No domestic use groundwater withdrawal wells have been identified at PGDP; potable water is obtained from the Ohio River.

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F.3.2.1 Potential Future Onsite Land Use

Risk assessment requires evaluation of alternative future uses. *Risk Assessment Guidance for Superfund (RAGS)* directs that alternative future land use should be based on available information and professional judgment considering master plans, Bureau of the Census projections, and established land-use trends in the general area and in the area immediately surrounding the site. A consistent policy for future land use assumptions for waste management areas is currently being developed and will be submitted to EPA for review. Based on current policy, SWMUs 2 and 3 are within the onsite secure area where the future use is considered to be industrial.

Industrial land use is appropriate for areas within the PGDP security fence because the PGDP is an operating industrial facility owned by the federal government. It is reasonable that the federal government will maintain control of the waste management facilities within the PGDP and that such government control will prevent residential use of this site. This future land use designation is consistent with current DOE Oak Ridge Operations policy.

Alternative industrial uses in the area of SWMUs 2 and 3 could increase the frequency of the exposures at this site. In addition, industrial development in this area may increase exposure to shallow subsurface contaminants (to 6 ft).

The onsite residential scenario is evaluated for a time in the future when the DOE and the federal government cannot be assumed to exist with 100% certainty .In the event that current policy and land use restrictions no longer apply, it would be possible that residents would build houses onsite, and use groundwater for drinking purposes.

Groundwater in the RGA is considered a potential source of potable water. This groundwater is not expected to be used as a potable water supply under the future industrial use; however, contaminants from this area may contribute to offsite groundwater contamination. The UCRS is not considered a potential source of potable water, but may represent conservative concentrations for continuing releases to the RGA.

Therefore, future onsite and offsite residential use of groundwater is addressed in this risk assessment by considering both the RGA and UCRS at the edge of the SWMU as potential sources of potable water. Additional risk characterization will be conducted for the groundwater integrator au. That characterization will assess residential use of onsite groundwater by considering leaching of contaminants from soil to groundwater. That evaluation will not be SWMU-specific, but will address the PGDP as a whole.

F.3.2.2 Potentially Exposed Population

This assessment evaluates potential risks for onsite workers and less frequently exposed workers or intruders as well as future onsite and offsite residents. The following receptor populations were considered for the land use at SWMUs 2 and 3:

F.3.2.3 Analysis of Exposure Pathways

Exposure may occur when contaminants migrate from the source areas to an exposure point or when a receptor comes into direct contact with waste or contaminated media at the site.

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F.3.2.4 Onsite Worker Exposure to Onsite Contaminated Soil

Onsite workers and worker/intruders may be exposed to onsite contamination in surface soils by ingestion, dermal absorption, inhalation of dust, and/ or external radiation exposures. These direct contact exposures typically occur from contact with the upper few inches of soil. However, because only two surface soil samples (zero to 1 foot below land surface) were taken at SWMUs 2 and 3, concentrations of constituents in the upper 6 ft of soil are considered for potential receptor contact.

Because the burial grounds are within the secured area, worker/intruders are not expected to encounter chronic exposure to soil contaminants at SWMUs 2 and 3 under current exposure assumptions. The area may become more accessible in the future industrial exposure setting.

Alternative future industrial uses may increase the frequency of onsite worker exposure and as a result of disruption of soils may bring constituents in the deeper soil zones to the surface. However, the deeper soils may contain the more mobile contaminants, like TCE, that are unlikely to present long-term chronic exposures at the surface.

F.3.2.5 Direct Intrusion into Waste Pit

In the event that the existing clay cap on SWMU 2 is not fortified and that future long-term weathering erodes the cap, it may be possible for the waste now buried to become more easily accessed. Future onsite workers, intruders, and residents may dig into the waste unit itself (for whatever reason). A qualitative analysis of the direct intrusion will be made, regarding the pyrophoricity of uranium metal shavings and other potential hazards associated with SWMU 2. SWMU 3 is not considered to be as potentially accessible in the future, considering the constructed and maintained RCRA cap.

F.3.2.6 External Radiation (Gamma) from Buried Uranium Waste

Onsite workers and future residents may be exposed to gamma radiation coming from the buried uranium waste. An onsite gamma survey conducted in July 1994 by MMES health physicists indicates that the gamma dose is highest at the north side of SWMU 2, which receives gamma radiation IIshine" from the cylinder yards. The drop in gamma readings from about 240 ILRem/hour to about 100 ILRemlhour, suggests that the" shine" from the cylinder yard may be contributing over half of the gamma dose at the area surrounding SWMU 2. In the absence of conclusive evidence, the gamma readings taken at SWMU 2 will be taken at face value and not adjusted for actual contribution from SWMU 2 alone.

F.3.2.7 Migration of Contaminants to Surface Waters

Transport of contaminants from SWMU 2 to surface waters is not a probable migration pathway, but has been identified as a reasonable deviation. This area is relatively level and has a clay cap over the waste, reducing potential releases with runoff. The interpretation of the surface migration pathway presented in Section 2.4 suggests that the contamination appears to coincide with the ditches surrounding the former burial grounds and leading to Outfall 015. Potential releases to offsite surface water will be evaluated as part of the surface-water integrator au. SWMU 3 is not considered a source of offsite contamination in surface water.

F.3.2.8 Migration of Contaminants to Air

Transport of contaminants to air as a result of dust generation has been identified as a reasonable deviation. SWMUs 2 and 3 are vegetated or covered; however, due to the low mobility of some constituents,

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they may be present in soil in the future and may be released should the vegetation be disturbed. The evaluation of potential risk from inhalation of contaminants associated with dust in air by onsite workers provides a conservative mechanism to screen the potential contribution of surficial contaminants to the air integrator au.

F.3.2.9 Migration of Contaminants to Groundwater

Both former burial grounds are likely sources of contamination of offsite groundwater. Uranium, metals, TCE, and Tc-99 were reported in subsurface soils within the unit and in the UCRS adjacent to the units and to a lesser extent in the RGA, but not in the groundwater downgradient of the units. The migration of groundwater contaminants and the resulting impacts and potential actions will be assessed during evaluation of the groundwater integrator unit. The purpose of this analysis of the" source" area is to evaluate potential future risks associated with groundwater uses.

Future conditions may lead to solubilization and mobility of the buried uranium waste as SWMU 2. The Summers model has been used to estimate uranium concentrations that potentially could be found in UCRS and RGA groundwater in the future. The risks presented by this scenario are evaluated for a future onsite resident ingesting UCRS and RGA groundwater. No wells at the PGDP withdraw water from the onsite groundwater because water is being supplied from the Ohio River for both potable and industrial use. Therefore, under industrial land-use conditions, there is no complete exposure pathway for the onsite groundwater contamination.

Groundwater wells were a primary source of water for offsite residential use in the area surrounding PGDP. In November, 1993, the Department of Energy implemented a Water Policy for the PGDP. All residences and businesses within an affected area north of the plant have been provided municipal drinking water, at DOE expense, as of May 31, 1994. These plant neighbors have agreed not to use existing groundwater wells nor to install any future wells. All existing wells are being locked and capped by DOE. A draft-final Water Policy was submitted in June, 1994, to incorporate (EPA/KDEP) regulator comments. The downgradient groundwater will be conservatively evaluated for offsite residential exposure for the following reasons:

The potential exists for continuing or future releases to the groundwater integrator unit from onsite wastes or contaminated soils at levels of potential current or future concern. In particular, uranium metal shavings are disposed in drums containing oil; future deterioration of the drums could result in release of the uranium and oil contents, with subsequent potential migration to groundwater.

The UCRS has a relatively low permeability, and transport of groundwater in that zone is downward. The RGA is the primary aquifer unit where sufficient yields would be present for water supply use and where contaminants would be transported offsite. Estimation of chemical concentrations in offsite groundwater will not be determined by fate and transport modeling, but will default to concentrations measured in onsite groundwater. As previously discussed, contaminant concentrations are generally higher in the UCRS. Therefore, contamination within the UCRS will be used to calculate a conservative reasonable maximum risk estimate. Contaminant contaminations within the RGA will be used to calculate a most likely risk estimate.

F.3.2.10 Chemical Hazard Identification

The mode of action currently associated with chemicals that exhibit carcinogenic and noncarcinogenic effects marks the division between the categories of contaminants. Even though the contaminants have been divided into categories of carcinogens or systemic toxicants, some elicit both types of effects. In addition, this

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assessment distinguishes between the chemical and radiological effects of contaminants, even though the final result (cancer) is the same. The potential risks for chemicals and radionuclides are not combined.

Some of the chemical contaminants that may contribute to risks at this site include pentachlorophenol; 2,4-Dinitrotoluene; N-nitroso-di-n-propylamine; OCDD; phenolic compounds; and the metals beryllium, arsenic, lead, chromium, barium, manganese, and soluble salts of uranium. Metals that have been identified are naturally occurring and, consequently, interpretation of these results must consider background effects.

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APPENDIX G

3-DIMENSIONAL DATA VISUALIZATION

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Appendix G
3-Dimensional Data Visualization Models

Directions:

Ensure the User has administrator privileges on the computer.

Insert Appendix G CD into CD or DVD drive.
The "4D Site Models BGOU Paducah, Kentucky" menu-driven viewer will automatically start up.
Click "File" and "Close" for the initial setup.
Click the Windows Start button.
Click "Run." On the command line, type "**x:**\viewer.exe" where **x:**\ points to the CD/DVD drive on which the CD has been placed (e.g., in most cases this will be "D," so the command line will normanlly read "D:\viewer.exe").
Click "OK."
Click "Next."
Click Next to install the 4D Interactive Model Player.
Select a new Installation folder or click "Next" to accept the default location.
Select "Next."
Read the License Agreement and check "Yes" if you agree with all the terms of the license agreement.
Click "Next."
Click "Next."
Once installation is complete, click "Finish."

The CD/DVD drive can then be opened and closed to initiate the "autorun" process, or the CD/DVD drive can be double-clicked from "My Computer."

The "4D Site Models BGOU Paducah, Kentucky" menu-driven viewer will automatically start up.

Any of the Groundwater Models or Soil Models may be selected to view. The 4D Interactive Model Player will appear in a separate screen.

Selecting any of the Groundwater Data or Soil Data files will open an Excel spreadsheet containing the data.

Files included on this CD are listed on the following pages.

4-D IM Setup – Program required to be installed to run 3-D models.

Groundwater directory with the following files:

- SWMU 2 3 4 groundwater (Microsoft Excel®) – file with data used to create models
- SWMU 5 historic GW (Microsoft Excel®) – file with data used to create models
- SWMU 6 historic GW (Microsoft Excel®) – file with data used to create models
- SWMUs 7 and 30 groundwater (Microsoft Excel®) – file with data used to create models
- SWMU 145 groundwater (Microsoft Excel®) – file with data used to create models

4-D IM Files

- SWMU 2and3and4_Carbon_tetrachloride
- SWMU 2and3and4_Manganese
- SWMU 2and3and4_Methylene_Chloride
- SWMU 2and3and4_TCE
- SWMU 2and3and4_Tec99
- SWMU 2and3TCE_Plot
- SWMU 2and3Tec99_Plot
- SWMU5and6_Iron
- SWMU5and6_Manganese
- SWMU5and6_Neptunium237
- SWMU5and6_Radium226
- SWMU5and6_singleDetectionUranium238
- SWMU5and6_Tec99
- SWMU7and30_TCE
- SWMU7and30_Tec99
- SWMU7and30_VinylChloride
- SWMU145_TCE
- SWMU145_Tec99

Soil-Sediment directory with the following files:

BGOU Soil Data to be Mapped (Microsoft Excel®) – file with data used to create models

4-D IM Files

SWMU2_Aluminum
SWMU2_Arsenic
SWMU2_TCE
SWMU2_Vanadium
SWMU4_Aluminum
SWMU4_Beryllium
SWMU4_cis12DCE
SWMU4_Manganese
SWMU4_Neptunium237
SWMU4_PCB1254
SWMU4_PCB1260
SWMU4_Radium226
SWMU4_TCE
SWMU4_Tec99
SWMU4_Uranium
SWMU4_Uranium235
SWMU4_VinylChloride
SWMU5and6_Beryllium
SWMU5and6_Manganese
SWMU5and6_Vanadium
SWMU5and6_Aluminum
SWMU5and6_Arsenic
SWMU5and6_Benzaanthracene
SWMU5and6_Benzoabfluoranthene
SWMU5and6_Cesium137
SWMU5and6_PCB1260
SWMU5and6_Radium226
SWMU5and6_TCE
SWMU5and6_Thorium228
SWMU5and6_Uranium
SWMU5and6_Uranium235
SWMU7and30_Aluminum
SWMU7and30_Antimony
SWMU7and30_Arsenic
SWMU7and30_Benzaanthracene
SWMU7and30_Benzapyrene
SWMU7and30_Benzoabfluoranthene
SWMU7and30_Beryllium
SWMU7and30_Cesium137
SWMU7and30_Manganese
SWMU7and30_Neptunium237
SWMU7and30_PCB1260
SWMU7and30_TCE_noDetections
SWMU7and30_Tec99
SWMU7and30_Uranium
SWMU7and30_Uranium234
SWMU7and30_Uranium235
SWMU145_Aluminum
SWMU145_Americium241
SWMU145_Aresenic
SWMU145_Beryllium
SWMU145_Cesium137
SWMU145_Polychlorinated
SWMU145_TCE_noDetections
SWMU145_Tec99
SWMU145_Uranium
SWMU145_Uranium235

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